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Cardiff Road
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1. Your reference — DE/J088207PGB

2. Patent application number *(The Patent Office will fill in this part)* — **9816796.8**

-3 AUG 1998

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Henrob Ltd
Aber Park
Flint
Flintshire
CH6 5EX

Patents ADP number *(if you know it)* 5934112001

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Improvements in or Relating to Fastening Machines

5. Name of your agent *(if you have one)* — Marks & Clerk

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Sussex House
83-85 Mosley Street
Manchester
M2 3LG

Patents ADP number *(if you know it)* 18004

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

| Country | Priority application number *(if you know it)* | Date of filing *(day/month/year)* |
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

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8. Is a statement of Inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
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11. I/We request the grant of a patent on the basis of this application.

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12. Name and daytime telephone number of person to contact in the United Kingdom — Mr. Dave Every (0161 236 2275)

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# IMPROVEMENTS IN OR RELATING TO FASTENING MACHINES

The present invention relates to fastening machines and in particular to improved aspects of fastener delivery to and around a fastening machine including a method for the controlled and efficient flow of fasteners from their point of manufacture to their insertion in a workpiece.

The term "fastener" is used herein to include rivets, screws, slugs and other types of fastening devices.

Conventionally rivets are presented to a fastening machine in loose form (e.g. they are delivered to the site in a bag which is severed and unloaded into a hopper of the machine) or mounted in a carrier tape. In the former design the rivets are extracted singly from the hopper and delivered to a rivet setting tool via a pressurised delivery tube in which the rivet is propelled by, for example, pressurised air. At the end of the delivery tube the rivet is typically transferred to an alignment or retaining device for holding the rivet in alignment with a rivet delivery passage of the setting tool. When the rivet is in this position a punch descends along the rivet delivery passage and drives the rivet into the workpiece so that it is deformed by an upsetting die disposed below the workpiece. In designs which use carrier tape the fasteners are advanced with the tape so that they are brought sequentially into alignment with the punch and die assembly by a feeder before the punch is actuated to drive the fastener out of the tape and into the workpiece as before.

In certain applications where limited space is available the use of a conventional carrier tape and feeder design is precluded by their size.

A present requirement in the industry is to meet the demands of large scale continuous production in which setting tools are supplied in a continuous uninterrupted manner both during operation of the setting tool and during robot dwell times when the setting tools are not in operation. In such fastening machines rivets are preferably transferred in bulk from a store or goods inward station to the setting tool on a production line in a "Just-in-Time" manner by automatic means such as, for example, auto-guided vehicles, robots or conveyors.

A problem with presenting loose rivets or other fasteners to conventional fastening machines is that the supply hopper or other storage device is topped up from time to time with fasteners that can be from different production batches, making it impossible to trace with any accuracy the passage of individual rivets or batch of rivets from the source of manufacture through to insertion in the workpiece. The mixing of batches compromises strict quality control measures demanded by modern industry, especially in the event of having to recall a riveted product. Operator error or non-compliance with procedures (e.g. adding rivets from an unidentifiable source to a feeder containing identifiable rivets) can exacerbate this difficulty.

A disadvantage of existing rivet delivery tubes is the tendency for them to wear during use because the plastics material from which they are generally constructed is selected as a compromise between flexibility, visual transparency (so that blockage or jams can be detected by visual inspection) and a low coefficient of friction. This is particularly so if rivets are fed sideways (i.e. at right angles to the longitudinal axis of the rivet) which is necessary if tumbling of the rivet within the tube is to be avoided. Fasteners having different aspect ratios (fastener length to head diameter) are fed in different orientations. For example, fasteners with a low aspect ratio are susceptible to tumbling in the delivery tube which must therefore be of T-shape or rectangular cross-section and fasteners with a high aspect ratio are transported axially in tubes of circular cross-section. Wear can manifest itself in the form of internal corrugations which can severely limit the propulsion velocity. In addition, the accumulation of dust and general detritus can cause blockages thereby interrupting the fastening process particularly as it is generally difficult to gain access to the interior of the tube. Such delivery tubes are generally connected to robotic devices and can be twisted or otherwise contorted during robot manipulation, particularly when routed around a bend having a small radius. In such cases the inner profile of the tube can be distorted to an extent that rivets become trapped in a constriction in the tube.

Another problem with sideways delivery of rivets is that they need to be rotated through $90^0$ before they can be inserted into the delivery passage of the nose

when the delivery tube approaches the nose from a vertical direction that is parallel to the setting tool axis. This can be done by incorporating bends into the delivery tube or feeder tube of a transfer station however this occupies considerable space since the bend must be gradual enough so to prevent jamming of the rivet and to maintain sufficient rivet momentum. Generally the transfer station has a plunger that directs a rivet emerging from the delivery tube into the nose of the setting tool. The delivery tube must therefore enter the transfer station ahead of the plunger in which case the tube must bend around the plunger, or the plunger must be constructed so as to reciprocate out of the path of the tube when a rivet arrives.

In certain fastening applications several rivet sizes are required for a workpiece or section of a workpiece if, for example, it comprises overlapping sheets or there is a requirement to attach a bracket to another component, in which case the sandwich thickness of the workpiece varies from two sheets to three sheets or more. When self-piercing riveting technology is employed, one of the factors determining the strength of a riveted joint is the length of the rivet in relationship to the sandwich thickness of the material to be fastened. The mechanical properties of joints riveted with the same size of rivet will vary depending on the sandwich thickness and the material being fastened. In a continuous production environment, conventional self-piercing riveting tools are dedicated to a single rivet size and the problem of riveting combinations of different thicknesses of material is addressed by using several dedicated tools each applying a different rivet size. Obviously this requires careful planning as increased combinations of different joint thicknesses and strengths require additional rivet sizes and therefore increased numbers of tools.

Finally, it is a continual requirement to improve the efficiency and reliability of the transfer of individual rivets from the delivery tube to the rivet delivery passage in the setting tool.

In many known setting tools rivets are transported directly into the nose via a permanently connected delivery tube. This arrangement has several disadvantages. In particular, the connection of the tube to the nose restricts access, is bulky and means that the tube must move up and down with the stroke of the nose during insertion of a

rivet into a workpiece. Moreover, the rivet delivery can be a problem in that there is no provision for dealing with a plurality of rivets that may have been accidentally fed into the nose and effective delivery relies purely on the momentum of the rivet as it travels down the delivery tube. It will be understood that the rivet momentum is variable with the air pressure supply (that propels the rivets along the tube), rivet mass and restrictions in the passage of the delivery tube (caused by kinks, bends, dirt and wear etc). In addition, the arrangement cannot prevent debris being carried into the nose along the delivery tube.

In applications where there is restricted access to a workpiece long slender noses are used and the rivet entry passage has to be positioned high up the nose so that long strokes of the punch within the nose are required. This increases the cycle time and adds significantly to the overall length of the setting tool.

Finally, there is generally a slow cycle time associated with such transfer arrangements. Rivets are fed separately to the nose and the cycle time is thus dependent on the length of the delivery tube.

In an alternative known configuration a transfer station is disposed between the nose and the delivery tube. Rivets stop at the transfer station and are transferred by a pusher into the nose. Whilst this arrangement reduces the cycle time in that rivets can be collected at the transfer station, the other disadvantages referred to above are not solved.

It is an object of the present invention to obviate or mitigate the aforesaid disadvantages.

According to a first aspect of the present invention there is provided a method for controlling the continuous flow of fasteners in a fastening machine wherein the fasteners are presented to the fastening machine in a succession of sealed containers that each bear manufacturing batch information and fastener identification data, the containers being used in a predetermined order relating to the manufacturing batch information, the fasteners being released from the container only when they have been secured to a feeder assembly of the machine and the fasteners from the previous container have been discharged from the feeder assembly, the manufacturing batch

information and fastener identification data being read and recorded by the machine before the fasteners are released.

According to a second aspect of the present invention there is provided a feeder device for a fastener machine comprising a hopper having at least one aperture into which a sealed container of fasteners is releasably secured, a gate which is moveable relative to the hopper between positions which open and close the aperture and a reservoir into which released fasteners are dispensed, wherein the container has a frangible seal that is broken when the feeder device is satisfied that the contents are correct so as to release the fasteners, the gate moving to the open position to pass the fasteners to the reservoir.

According to a third aspect of the present invention there is provided a feeder device for a fastening machine comprising a support on which are mounted a plurality of containers each containing fasteners arranged in vertical array, and a release mechanism that is moveable relative to an underside of the support, the release mechanism comprising a carriage captively fitted to the support and a chamber for receiving at least one fastener from a container, an actuator for directing the fastener out of the carriage into a delivery tube and release means for releasing a fastener from the container.

According to a fourth aspect of the present invention there is provided a feeder device for a fastener machine comprising a tray defining a plurality of channels in which fasteners are received, a release gate with an aperture, the gate being removable relative to the tray so as to bring the aperture into register with a selected channel, and means for extracting the fastener from the channel.

According to a fifth aspect of the present invention there is provided a feeder device for a fastener machine comprising a flexible sealed bag defining a plurality of sealed channels containing fasteners, a blade for severing a selected channel so as to release the fasteners and a reservoir into which the fasteners are released.

According to a sixth aspect of the present invention there is provided a setting tool for a fastening machine comprising a nose piece with a fastener delivery passage therein, a magazine housing a plurality of fasteners and a transfer station for

transferring a fastener from the magazine to the fastener delivery passage, the magazine comprising at least one column for housing aligned fasteners, an inlet to the column for loading fasteners, and an outlet from the column for feeding the transfer station.

According to a seventh aspect of the present invention there is provided a fastener delivery tube for interconnecting a setting tool to a source of fasteners, the tube having an internal passage through which fasteners may pass and at least one wear resistant strip that projects into the passage to contact the fastener.

According to an eighth aspect of the present invention there is provided a fastener machine comprising a setter tool having a nose with a fastener delivery passage therein, a faster delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage, a transfer device attached to one end of the delivery tube and moveable relative to the nose, a stop member at the end of the delivery tube for stopping a delivered fastener and an actuator for moving the transfer device between a first position in which an exit of the station is adjacent the nose so that a delivered fastener at the stop member is inserted into the delivery passage and a second position in which it is clear of the nose so as to permit the nose to move towards a workpiece to insert a loaded fastener.

According to a ninth aspect of the present invention there is provided a fastener machine comprising a setter tool having an actuator reciprocal along a path to drive a fastener into a workpiece, a fastener delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage and a transfer device between an end of the delivery tube and the actuator, the transfer device comprising an inlet passage contiguous with the end of the delivery tube and an exit from the transfer station, the inlet passage not been aligned with the exit and a gate intermediate the inlet passage and the exit, the gate being moveable between a closed position in which it prevents movement of a fastener out of the inlet passage and an open position in which it permits a fastener to pass to the transfer station exit.

According to a tenth aspect of the present invention there is provided a delivery tube comprising at least first and second inlet branches connected to a single

outlet branch, and a gate being disposed between the inlet and outlet and being operable to close communication between one of the inlet branches and the outlet branch.

According to an eleventh aspect of the present invention there is provided a fastener machine comprising a setter tool having a nose with a fastener delivery passage therein, a faster delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage, a transfer device disposed between one end of the delivery tube and the nose and defining a transfer path, the transfer device having a rotation device for rotating the fastener through substantially a right angle so that it is correctly oriented for entry into the fastener delivery passage, the rotation device comprising a carriage that is moveable along the transfer path toward the fastener delivery passage and is designed to receive a fastener from the delivery tube and a cam surface that causes the carriage to rotate through a right angle as it moves align the transfer path, and a plunger for moving the rotated fastener out of the carriage into the fastener delivery passage.

Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic view of a riveting machine in accordance with the present invention;

Figure 2 is a perspective view of a container of rivets shown without an exterior sleeve;

Figure 3 is a perspective view of the container of figure 2 shown with an exterior sleeve that is partially cut away for clarity;

Figure 4 is a schematic sectioned view of part of a loading station of the riveting machine showing rivets being loaded into a central feeder from a first container;

Figure 5 is a view in the direction of arrow B of figure 4;

Figure 6 is a view in the direction of arrow C of figure 5;

Figure 7 is a schematic sectioned view of the loading station of figure 4 showing it in an intermediate state between unloading of first and second containers (not shown);

Figure 8 is a schematic sectioned view of the loading station of figure 7 showing unloading of the second container (not shown);

Figure 9 is a schematic perspective view of a plurality of first alternative embodiment rivet containers loaded on to a pallet;

Figure 10 is a diagrammatic representation of one of the containers of figure 9;

Figure 11 is a schematic side view representation showing unloading of rivets from a container on the pallet of figure 9;

Figure 12 is a diagrammatic representation of the path followed by a release mechanism relative to a container;

Figure 13 is a fragmentary perspective view of a second alternative embodiment of a rivet container;

Figure 14 is a fragmentary perspective view of a similar container as shown in figure 13 with the rivets shown pre-orientated;

Figure 15 is an end view the container of figure 13 mounted on a rotary drum;

Figure 16 is a plan view of a third alternative container embodiment in an unfolded configuration;

Figure 17 is an end view of the container of figure 16 shown in a folded configuration;

Figure 18 is a perspective view of the container of figures 16 and 17 being fed to a rotary release device;

Figure 19 is a schematic representation of a release mechanism of the device of figure 18;

Figure 20 is a perspective schematic view of a fastener machine according to an aspect of the present invention;

Figures 21 and 22 are side views of a first embodiment of a rivet magazine and transfer station of the present invention with a setting tool nose shown schematically;

Figure 23 is a front view of the embodiment shown in figures 21 and 22;

Figures 24 and 25 are side and front views respectively of a second embodiment of the rivet magazine and transfer station;

Figure 25a shows an embodiment of a rivet magazine in combination with a motorised rotary auger in accordance with an aspect of the present invention;

Figures 26a to 26t are cross section views through alternative embodiments of a rivet delivery tube in accordance with an aspect of the present invention;

Figure 27 is a plan view of a forked delivery tube of the present invention in which a side limb is used to deliver compressed air;

Figure 28 is a sectioned plan view of a dual entry delivery tube according to one aspect of the present invention;

Figure 29 is a perspective sectioned end view of the delivery tube of figure 28;

Figures 30 and 31 are side views of a setting tool with a first embodiment of a transfer station in accordance with an aspect of the present invention showing the transfer station in two different positions;

Figure 32 and 33 are side views of a setting tool with a second embodiment of a transfer station shown in two different positions;

Figures 34 to 37 are plan part sectioned views of a nose and transfer station in accordance with an aspect of the present invention, showing the internal structure thereof;

Figure 38 is a side view of the mechanism of figure 34;

Figures 39 to 43 are views of a modified embodiment of the transfer station of figures 34 to 38 in which the rivet setter has no supporting nose;

Figures 44 and 45 are part sectioned side views of alternative embodiments of the transfer station of figure 43;

Figures 44a and 45a are sectioned plan views of the punch and pre-clamping member of figures 44 and 45 respectively.

Figures 46 to 53 are part sectioned side views of a transfer station and rivet setter nose in accordance with an aspect of the present invention;

Figure 54a-54d are schematic views of a modified rivet retaining device for use in the transfer station of figures 46 to 53;

Figure 55 is a sectioned side view of an alternative embodiment of a transfer station for transferring a rivet from a delivery tube to a nose of a setting tool, showing a rivet in a retained position;

Figure 56 is a scrap end view of the embodiment of figure 55;

Figure 57 is a side view corresponding to figure 54 with the rivet shown in a released position;

Figure 58 is a side view corresponding to figure 54 with the rivet shown loaded into the nose of a setting tool;

Figure 59 is a part sectioned side view of a further alternative embodiment of a transfer station for transferring a rivet from a delivery tube to a nose of a setting tool; and

Figure 60 is a view in the direction of arrows A-A of figure 59; and

Figures 61 and 62 are plan views of a multiple entry transfer station with a rotary gate;

Referring now to the drawings, figure 1 shows a fastening machine that comprises a setting tool 1 mounted on a conventional C-frame 2 above a rivet upsetting die 3. Rivets are presented to the machine in the form of one or more containers or packages 4 ( one only shown schematically in figure 1).

A rivet release mechanism 5, disposed below the container 4, serves to permit rivets to escape from the container one at a time into a delivery tube 6 by which they are transported to the setting tool 1. A typical means of transport is by blowing compressed air along the delivery tube to propel the rivet therealong. At the setting tool end of the delivery tube 6 the rivet is captured by a transfer station 7 which serves to transfer the rivet to the nose 8 of the setting tool 1 and ensures that it is in correct alignment with a punch (hidden) prior to insertion of the rivet into a workpiece.

Figure 2 shows an example of a rivet container in the form of a transparent plastics, substantially parallelepiped box 9 with a sealed lid 10 on its upper face. The lid 10 of the container has a peripheral lip 11 by which it is located in a loading station (see below) and tear perforations 12 along three sides. The edge of the fourth side has a pull strip 13 so that the lid 10 can be torn away from the rest of the

container along the perforations 12. One edge of the lip 11 has a plurality of machine readable notches 14 that represent coded information relating to the contents of the container e.g. rivet type, size etc. A side wall 15 may be embossed with the manufacturer's name and other relevant information and an end face 16 of the container ideally bears a bar code and printed information relating to the rivet part number and the batch number.

The plastics container 9 is received in a cardboard sleeve or box 17 as shown in figure 3 in order to provide strength for storing or transporting in bulk. The box 17 is printed with relevant information relating to the correct use of the rivets. An end wall 18 of the box 17 has a window 19 so that the transparent plastics container 9 and the printed information thereon can be inspected.

Two plastics containers 9 containing rivets are shown in position on a loading station in figure 4. The loading station comprises a central feeder 20 from which a chute 21 extends upwardly towards the containers 9 which are received in apertures 22 in an arcuate hopper 23. The chute 21 is connected to a rotary gate 24 that underlies the hopper 23 and which is rotatable relative thereto. A full container 9 is presented to the hopper 23 with its lid 10 intact by inverting it and sliding the lip 11 under the edges of one of the apertures 22 until it is in the position shown in figure 4, whereupon the rotary gate 24 moves to the position shown in figure 7 thereby preventing removal of the containers 9.

When the machine operator is satisfied that the container 9 is correctly in place (sensors may be provided to indicate this) the loading cycle is commenced. First a key plate 25 (see figure 5) bearing protrusions 26 complementary to the notches 14 on the desired rivet container moves laterally towards the notched edge of the container lip 11 and checks that the notches 14 are correct for the type of rivet required. At the same time a bar code 27 reader scans the end of the container and transmits the information relating to the batch number etc. to a controlling computer. The gate 24 is then rotated in reverse and a release mechanism (not shown) engages the end of the pull strip 13 and winds it around a spool (not shown) so as to remove the lid 10 and release the rivets which then pass down the chute 21 and into the feeder 20.

The pull strip 13 may alternatively be removed by an operator. When the container 9 is unloaded it is removed and the gate 24 rotated to close the aperture 22.

Should the key plate 25 and/or bar code reader 27 establish that the wrong type of rivets have been loaded, the hopper 23 may be moved to a reject position (not shown) where the incorrect rivets are discharged to a reject bin.

When the empty container 9 is being replaced, the rotary gate 24 may index round so as to permit loading of the contents of the second container into the feeder 20 as shown in figure 8. However, the operation is controlled such that a container 9 is not unloaded until the feeder 20 is empty. This ensures that rivets from different containers are not mixed so that each batch of rivets is traceable. The containers 9 are designed so that they cannot be refilled and reused on-line thereby eliminating a risk of contamination of the riveting process by unidentifiable rivets (however, they may be refilled and resealed off-line). The above described arrangement ensures that incorrect rivets cannot be poured into the feeder 20 since the content of each container is automatically checked and verified before it is opened.

An alternative packaging configuration for rivets is shown in figures 9 to 12. Rivets 30 are pre-packed in rigid plastics containers 31 such that they are all oriented in the same way. Each container is divided by spacers 32 into a plurality of discrete elongate columns 33 (one shown in figure 11) which, as can be seen from figure 10, are of T-shaped cross section when viewed in plan. The rivets 30 are dispensed from each column 33 under gravity although a pusher mechanism (not shown) may be provided if required. A plurality of such containers 31 is mounted on a single pallet 34 under which is disposed one or more release mechanisms 35 by which the rivets 30 are extracted from the containers 31 and discharged into a delivery tube 36. In the embodiment shown in figure 9 the pallet 34 contains twenty five containers arranged in five rows (x-axis) and five columns (y axis). Each column of containers has an associated release mechanism carriage 35 that carries a delivery tube 36 and is captively engaged to the underside of the pallet 34 in such a manner that it is able to traverse relative thereto in the x and y axis directions. Each container 31 contains

rivets 30 of the same type although the pallet may support different containers so that a combination of rivet types may be supplied according to the particular application.

Each release mechanism carriage 35 is of a size to accommodate a rivet 30 in two positions. On one side of the carriage 35 there is an aperture 37 facing towards the pallet 34 that is designed to receive a rivet from the container and adjacent thereto facing away from the pallet 34, is a second aperture 37 that connects the inside of the carriage 35 to the delivery tube 36. Opposite the second aperture 37 there is an upstanding guide pin 38 that projects into a guide track 39 formed as a groove on the underside of the pallet 34. The guide track 39 under a single container 31 is diagrammatically represented in figure 12.

The pallet 34 is disposed in an inclined position (as shown in figure 11) so that the carriage 35 moves along the y-axis direction under gravity. In order to release rivets from a container 31 the carriage 35 first traverses along the x-axis under the influence of a suitable actuator such as a motor and at the end of the first pass in the x axis direction of the guide track 39 it moves at right angles under gravity along the portion indicated by reference numeral 40 in figure 12 of the groove 39 to the next pass in the x-axis. As the carriage 35 indexes along in the x axis direction the guide pin 38 engages and opens a gate 40a at the end of each column 33 of rivets 30 in the container 31 thereby permitting the lowermost rivet in the column 33 to fall under gravity into the carriage 35. When the presence of the rivet is detected in the carriage 35 a pusher 41 on the carriage is extended to move the rivet 30 laterally until it is over the delivery tube aperture 37 whereupon a blast of air is directed at the rivet 30 to propel it into and along the delivery tube 36. A shutter (not shown in figure 10) prevents air from entering the rest of the carriage 35 or the container 31. When the carriage 35 continues along its path the pin 38 disengages from the gate 41 which then automatically closes behind the carriage 35.

The pallet 34 may be arranged such that each column of containers (y axis) has a different rivet type so that each carriage 35 and delivery tube 36 is of a different size and shape to accommodate the particular type of rivet 30. The movement of each carriage 35 is controlled by a computer operated control program that issues

movement instructions to the appropriate carriage according to the type of rivet that is required at any stage in the riveting process.

In figure 13 there is shown a further alternative packing configuration in which rivets 50 are housed in a moulded rigid plastics corrugated tray 51 defining a plurality of V-shaped channels 52 in each of which rivets 50 are received. The rivets 50 may be pre-orientated as shown on the right hand side of figure 13 or randomly orientated as shown on the left. In the latter case an orientation device (not shown) is required downstream of the tray. A plastics cover 53 overlies the tray 51 to retain the rivets 50. If several trays 51 are required they may be vertically stacked with covers in between. A second cover 54, shown beneath the tray 51 in figure 13, enables rivets to be contained on both sides of the tray. The rivets 50 are released from the end of each channel 52 by gravity feed. An alternative tray embodiment 51 with U-shaped channels 52a is shown in figure 14 with the rivets 50 pre-orientated. The ends of the trays 51 of figures 13 and 14 are covered with a closure plate (not shown) that has an aperture which enables rivets 50 to be released from a selected channel 52. As shown in figure 15 the tray 51 may be arranged over a rotary drum 55 that is indexed relative to a stationary closure plate (not shown). The rivets 50 are shown oriented in two alternative configurations in figure 15; on the left there are shown short rivets 50a oriented with their longitudinal axes in a radial direction and on the right the longer rivets 50b are shown oriented with their longitudinal axes in an axial direction along the length of the drum 55. The rivets 50a, 50b may be removed from the tray 51 using other methods as an alternative to a gravity feed, for example, external vibration, magnets, vacuum, pressurised air or an electro-mechanical pusher or other actuator.

Figures 16 to 19 show another alternative packaging configuration in which the rivets are contained in an elongate flexible plastics bag 60 that is heat sealed to define a plurality of parallel channels 61 in which rivets 62 are housed. The channels 61 extend in a direction transverse to the length of the bag 60 which is folded for storage (as shown in figure 17) so that the channels 61 are nested.

In use, the bag is 60 is unwound around a rotary drum 63 that is axially slotted around part of its circumference as shown in figure 18. The drum 63, which

may be slotted around the whole circumference in other embodiments, indexes about a central shaft 64 past a release station 65 that comprises a release channel 66 and a perforation blade 67 that both extend parallel to the longitudinal axis of the drum 63. The release channel 66, which is substantially V-shaped in cross-section, is disposed radially outboard of the drum 63 and the perforator blade 67, which has a segmented blade edge 68, is disposed adjacent thereto, radially in-board of the drum 63. As the bag 60 passes the release station 65 the perforator blade 67 indexes radially outwards and passes through a slot 68a in the drum 63 to sever a channel 61 of the bag 60 thereby releasing the rivets 62 which then fall into the release channel 66. The channel 66 is inclined and vibrated so as to allow the released rivets to enter a track (not shown) where they are orientated by a known mechanism before being discharged into a delivery tube (not shown).

In an alternative configuration (not shown) the bag is stored in a spiral configuration.

The plastics bag 60 may be heat shrunk as well as heat sealed so as to confine individual rivets in blisters thereby preventing turning or rubbing of the rivets within the bag 60.

In alternative embodiments (not shown) the end of the bag 60 is severed and the rivets 62 are removed by using a vacuum source, pressurised air, gravity, vibration, a magnet or a pusher.

The packaging designs described above eliminate the need for an open hopper or reservoir of rivets and as they effectively provide a sealed system operators are prevented from introducing unidentifiable rivets into the fastening machine.

Rivets from any of the container configurations described above may be fed via delivery tube (or track) 71 to a distribution manifold 72 as shown in figure 20. In the embodiment shown two hoppers 70 each receive rivets directly from an alternative design of rivet container that is connected directly to the hopper so that it forms a sealed unit therewith. The hoppers or containers feed two inlets 73 in the manifold 72 and the rivets are then distributed by the manifold 72 to one or more setting tools 75

via a plurality of outlet delivery tubes 74. The rivets travel in the delivery tubes under the influence of, for example, pressurised air or moving magnets.

At the setting tool 75 the rivets may be loaded into a magazine 76 removably fitted to the setting tool 75 or may be fed directly to the nose 77 of the setting tool via a transfer station 78. In the embodiment shown in figure 20 a magazine 76 is connected to the tool 75 and the end of the delivery tube 74 and is designed to receive a pre-determined number of rivets before passing them to the transfer station 78 that transfers individual rivets into the nose 77. The end of the delivery tube 74 is designed to store the pre-determined quantity of rivets to be held in the magazine 76. Example embodiments of the transfer station will be described later.

Example embodiments of magazines are shown in figures 21 to 25a. In each embodiment the magazine 80 is disposed on the setting tool adjacent the nose 81 and releases the rivets 82 individually to a transfer station 78. The rivets 82 are aligned in a vertical stack in the magazine 80 with new rivets 82 being supplied to an opening in an upper end 83 of the magazine 80 and being removed at a lower end 84. Side walls 85 of the magazine 80 are vertically slotted (at 86) to receive the rivet heads 87. The slots 86 serve to retain the rivets 82 in alignment and allow them to slide under gravity down the magazine 80 as rivets are removed from the lower end 84. The transfer station 78 in the embodiments shown is a rotary escapement wheel 88 that has peripheral slots 89 designed to receive a rivet head 87. When an empty slot 89 in the escapement wheel 88 is presented to the lower end 84 of the magazine 80 in correct alignment, the lowermost rivet falls under gravity or is transferred into the slot 89. The escapement wheel 88 is then rotated through $180^0$ where it is engaged by a reciprocating pusher arm 90 that moves the rivet 82 laterally out of the escapement wheel 88 and into the nose 81 of the setting tool. While the escapement wheel 88 is in this position a second slot 89, diametrically opposite the first, is able to receive the next rivet 82 thereby ensuring a continuous supply.

In alternative embodiments (not shown) the rivets may slide down the magazine under the influence of a driver such as a pusher or vibrator.

The embodiment of figures 21 to 23 shows a magazine with a single column of rivets 82 whereas the embodiment of figures 24 and 25 has two columns. In the latter embodiment the escapement wheel 88 is pivotal about a joint 91 between the two columns so that if one column becomes empty or jammed rivets can be drawn from the other column, and only one slot 89 is provided. The columns may alternatively contain different types of rivets. The pusher arm 90 may be driven by a rack and pinion mechanism 92 as shown in figure 24.

In figure 25a rivets are individually engaged in the magazine 93 by a motorised rotary auger 94, which transports them along the length of the magazine 93. A screw thread 95 of the auger 94 projects into spaces between the rivets 96 and is rotated to move the rivets 96 downwards in the magazine 93 towards the transfer station rather than allowing them to fall under gravity. A sensor (not shown) detects the presence of a rivet and controls the rotation of the motor. Alternatively the motor is supplied with a pulsed signal so that it rotates through one revolution at a time so as to displace rivets by one thread pitch of the screw (equivalent to the diameter of a rivet).

It is to be understood that any number of parallel columns may be provided in any particular configuration in a single magazine as is required by the application. The profile of each column may be T-shaped, rectangular , triangular, circular or otherwise shaped depending on the particular rivets in use.

It is to be appreciated that a single magazine may be loaded with a specific number of different rivet types in a predetermined sequence or a magazine with a plurality of columns may be loaded so that different rivets are segregated into the different columns.

In an alternative embodiment (not shown) the magazines are pre-loaded with rivets and presented to the setting tool by an operator or a robot in which case the delivery tube is not required at the setting tool. When a magazine is empty it is simply removed from the tool by the operator or robot and replaced immediately with a full magazine from an adjacent stock such as, for example, a carousel. The carousel mounted magazines may be loaded from delivery tubes, one dedicated to each

delivery tube. The empty magazine may then be disposed or refilled. By providing a plurality of magazines or columns within a magazine each containing the same rivet type the rivet setter operation is not interrupted if one magazine or column becomes jammed as rivets can be drawn from another source. Examples of these are described below.

In a further alternative embodiment (not shown) the setting tool nose and magazine are removable together as an interchangeable unit. This arrangement enables the same tool to set a variety of different rivets with relative ease and ensures that all rivets are removed from the tool at once. Moreover, the rivet feed path is not disturbed at each change as any unused rivets remain in the removed nose and magazine unit until it is next used.

The magazine and transfer station designs described above may be used in place of the containers referred to above so that they are remote from the setting tool. The released rivets are delivered to the setting tool by transferring the rivets to a delivery tube or the like via a transfer station.

Figures 26a to 26t show, in section, alternative embodiments of a rivet delivery tube such as the one that is used to shuttle rivets from a remote feeder such as a pre-packed container with release mechanism or a hopper, to the setting tool. The tubes may be manufactured from extruded plastics of one or more components or by folding a flat plastics sheet. Ideally they are transparent so as to assist in identifying blockages caused by trapped rivets and/or debris, and flexible to allow bending of the tube without distorting the internal profile of the tube significantly. The same configurations may be used as a magazine at the setting tool.

In figure 26a there is shown a rivet delivery tube 100 that is formed by a one-piece plastics extrusion (or a two-piece co-extrusion) having wear-resistant characteristics. The outer profile is approximately square but could be rectangular depending upon the size of the rivet. The internal profile of the delivery tube walls is configured to define a cavity 101 that is approximately T-shaped in cross-section so as to conform to the profile of the rivet except that it is slightly larger in size so as to allow the rivet pass easily along the tube 100. Immediately below the head portion

102 of the T-shaped cavity 101 there are opposed inwardly projecting ridges 103 that extend along the length of the tube 100 in parallel. A further ridge 104 projects downwardly from a roof of the cavity 101. The ridges 103, 104 serve as wear strips that ensure the rivet is correctly aligned in the tube and the areas of contact between the rivet and tube are kept to a minimum thereby reducing friction and tube wear.

The delivery tube 100 shown in figure 26b is of the same configuration as that of figure 26a with the exception that the wear strips 103, 104 are provided by a wire or chord insert. These may be snap-fitted, bonded or co-extruded in complementary grooves 106 in the internal wall of the delivery tube 100. This configuration has the advantage that the wear strips 103, 104 are replaceable (unless co-extruded) and can be made from a material different to that of the rest of the tube. If the wear strip is manufactured from an electrically conductive material it can be used to detect the position of a rivet (which is also electrically conductive) along the tube by inductive sensing thereby enabling the location of a blockage to be identified rapidly. The wear strip could alternatively be made in composite form (not shown) with a central core of electrically conductive material (e.g. copper) and an outer sleeve of wear-resistant material such as kevlar.

The delivery tubes of figures 26c and 26d are formed from releasably connectable upper and lower portions 100a, 100b. Separating the two portions 100a, 100b not only allows access to the cavity 101 to clear blockages or accumulation of debris etc. but also allows the portions 100a, 100b or wear strips 103, 104 (if removable) to be replaced by others of a different internal configuration or depth. The tube portions 100a, 100b are connected together by any known configuration of releasably engageable connection such as inter-engaging formations 106a, 106b defined on mating edges of the upper and lower portions 100a, 100b of the tube 100.

The embodiments of figures 26e to 26h illustrate how deeper lower portions 100b of the delivery tube 100 may be connected to accommodate longer rivets. In figure 26e there are shown three approximately square wear strips 107a, 107b, 107c that accommodate the head 108 of the rivet 109 and an elongate wear strip 110 upstanding from a base wall 111 of the lower portion 100b of the tube 100. The latter

wear strip 110 is designed to accommodate a rivet 109 having a medium length shank 112 but is readily interchangeable with a shallower strip to accommodate a rivet having a longer shank. Extra wear strips 113 are provided in the lower portion 100b of the delivery tube 106 of figure 26f so as to provide additional guidance for the rivet 109. In the tube 100 of figure 26g only two vertically opposed wear strips are provided. Again, either of the strips 114a, 114b may be replaced with ones of different heights depending on the rivet size. Figure 26h shows how a filler element 115 may be used to occupy part of the cavity 101 defined in the lower portion 100b of the tube 100 of figure 26f. The filler element has a protruding ridge 116 on each side that engages in the complementary groove 117 designed for a removable wear strip and serves to minimise air leakage in embodiments where the rivets 109 are projected by compressed air.

The delivery tube may be of modular construction as illustrated in figures 26i to 26l in which the top, bottom and side walls 120, 121, 122 are releasably engageable so that a delivery tube 100 of any desired size may be constructed. The walls are interconnected by any suitable form of clip or snap-connect formation 123 as shown in the figures.

In figure 26m there is shown a single-piece delivery tube 100 formed from a plastics sheet that is folded, bent round, blow moulded or extruded to form an enclosed tube. This design may also be used as a disposable magazine (in which case ends caps (not shown) are required to close fully or partially end openings of the magazine). The ends 124 of the sheet have complementary formations that are releasably inter-engageable to hold the tube 100 closed.

The delivery tube of figure 26n is similar in configuration to that of 26d except that the top wall 120 is partially cut away to reveal part of the rivet 109 thereby serving more as a delivery track. This provides ease of access to the rivet 109 in the event of a blockage. The track is flexible and can be used with gravity feed in a fixed setting tool.

A two-piece tube of configuration similar to that of figure 26m is shown in figure 26o. The lower portion 100b of the tube may be removeable (See fig 26p).

In the embodiment of figure 26p, the lower portion of the tube is absent (it may be removed or partially slid apart from the upper portion 100a) to provide access to the rivets 109 by a transfer station 125 which is in the form of a rotary escapement wheel such as that described above in relation to figures 21 to 25. The upper portion of the delivery tube effectively serves as the rivet magazine and can alternatively be used in conjunction with the rotary auger of figure 25a so that threads of the auger extend into gaps between the rivets and rotation of the auger carries rivets along the tube. In the embodiment shown, the rotary escapement wheel 125 engages the protruding shank 126 of the lowermost rivet 109 and transfers the rivet to the nose of the setting tool (not shown in figure 26p). In an alternative embodiment (not shown) the rivet 109 is orientated so that the escapement wheel 125 engages the rivet head 126a.

The upper portion 100a of a separable delivery tube 100 may be hinged to the lower portion 100b as shown in the embodiment of figure 26q. The hinge 127 is a flexible integral web interconnecting the upper and lower portions 100a, 100b at one side. On the other side the portions 100a, 100b are interconnected by releasable inter-engaging complementary portions 128 as before.

In the embodiments of figures 26r and 26s the upper and lower portions 100a, 100b have outwardly extending side flanges 129 that are held together by a removable clip 129a that extends continuously or intermittently along the length of the delivery tube 100 and is of a complementary formation to the flanges 128. Seals 130 are provided between mating faces 131 of the flanges 128 to prevent the ingress of dust, other foreign bodies, or moisture and the leakage of compressed air. In the embodiment of figure 26s the clips 129a are integrally connected to a rigid support frame 132 that is substantially channel shaped with upstanding side walls 133 between which the delivery tube 100 is received. The clips 129a extend inwardly of the channel 132 at an upper end of each upstanding wall 133. The support frame suspends the tube which may be routed throughout the factory delivering the rivets over long distances and may be used to join adjacent segments of a delivery tube so that they are in axial alignment.

The delivery tube 100 of figure 26t has been adapted to incorporate service cables required by the riveting machine including cables servicing compressed air booster points along the tube (described later) and gate elements at a multiple inlet delivery tube. The upper and lower portions 100a, 100b of the tube 100 have elongate outwardly extending lateral flanges 140 at each side. On the right of the tube 100 depicted in figure 26t the flanges are recessed at their mating faces 141 to define an enclosed chamber 142 that is designed to receive service cables 143 or the like. The cables 143 may carry, for example, pneumatic and electric power or electrical control signals. This design provides for a compact and neat arrangement. Moreover, the flat configuration of the tube 100 can help prevent the tube from twisting or being oriented incorrectly on instalment.

In an embodiment not shown, the wear-resistant strips are replaced with grooves or voids in the walls of the delivery tube. These create air channels that serve to cushion the rivet as it is propelled along the tube without it contacting the side walls.

It is to be appreciated that many of the features described above in relation to the wear resistant delivery tubes may be used in combination.

Propulsion of the rivets along the delivery tube is by pressurised fluid such as compressed air or by linear magnetic acceleration. Booster points can be provided along the length of the tube to ensure that sufficient compressed air or magnetic acceleration is provided along the full length of the tube for efficient operation. In order to provide compressed air booster points the delivery tube is segmented with adjacent lengths being interconnected by a booster segment of tube 150 (an example is illustrated in figure 27) having a main delivery passage 151 and a side limb 152 through which the compressed air is blown. The tube has a shutter 153 that is laterally moveable (in the direction of arrows shown) to close the main passage 151 when air is blown through the side limb 152 so as to prevent rivets 154 in the passage 151 being blown backwards. The tubes may have replaceable segments for those areas that are prone to wear or damage and may be pre-formed for features such as

bends and multiple inlet junctions (for example, where rivets are delivered from several sources via a plurality of subordinate tubes to a single main tube).

Rivets can be fed from the feeder either singularly or in groups in which case they are transported along the delivery tube in convoy. In a particular embodiment, not shown, rivets are loaded into a shuttle magazine at the feeder and the magazine is transported along the delivery tube to the setting tool where it is unloaded by any of the methods described above. The empty magazine can then be recycled. The magazine is typically transported by compressed air fed into the delivery tube. This arrangement has the advantages that rivets are less likely to be damaged by high speed propulsion, may be delivered at a faster rate in large quantities in a more reliable fashion and there is a lower rate of consumption of compressed air.

If necessary the delivery tube may be encased in an outer protective sleeve that is filled with a supportive material such as foam or the like.

A multiple inlet delivery tube is shown in figures 28 and 29 in which two supply branches 160a, 160b merge with a single exit branch 161. The internal configuration of the tube in the embodiment shown is T-shaped in cross section and may be an open channel as shown in figure 29 or an enclosed tube (not shown). This tube enables rivets from two different sources to merge into a single exit tube. The rivets in each supply branch 160a, 160b are typically of different types and therefore a gate 162 is provided at the intersection of the supply and exit branches 160a, 160b, 161. The gate 162 is pivotally mounted on a ledge 163 defined by the T-shaped profile on a wall 164 of the delivery tube at which the supply branches 160a, 160b meet, and extends across the tube to the opposite exit branch 161. In use, the gate 162 is pivotally moveable between two positions in which it closes communication between the exit branch 161 and one or other of the supply branches 160a, 160b. In the embodiment shown in figure 28 the incoming rivet 165 in the right hand supply branch 160b is free to pass into the exit branch 161 since the gate 162 is disposed so as to block the other supply branch 160a. However, with the gate 162 in the position shown in dotted line the rivet 165 is prevented from passing to the exit branch 161 unless the other supply branch 160a is clear in which case the momentum of the rivet

165 serves to pivot the gate 162 clear of its path. The gate 162 is configured to help guide the rivet 165 along its path by supporting it across a gap created by the intersecting branches 160a, 160b. It is to be appreciated that the gate may be free moving or mechanically driven.

An example of a transfer station for use in the present invention is shown in figures 30 and 31 in conjunction with a conventional rivet setting tool 170 which will not be described in detail. The transfer station 171 delivers rivets directly to a side port 172 of the nose 173 of the setting tool 170 from a delivery tube 174 as is well known. The inventive feature of this design is that the transfer station 171 is pivotable by an actuator 175 between the two positions shown respectively in figures 30 and 31. The actuator 175 shown is a hydraulic or pneumatic cylinder (but could be any suitable form of actuator) connected to the transfer station 171 by a system of linkages 176. In the position shown in figure 30, rivet passages (hidden) through the delivery tube 174 and transfer station 171 are in register with the side port 172 in the nose 173 so that a rivet can be loaded. When the rivet is loaded the nose 173 extends downwardly in a known manner to effect the riveting operation and at the same time the actuator 175 is operated so as to pivot the transfer station 171 and delivery tube 174 clear of the nose 173 providing sufficient clearance for the nose 173 to extend as is shown in figure 31. It will be appreciated that the delivery tube 174 need not be horizontally disposed as depicted in figure 30 but may arrive at the transfer station 171 at any convenient angle.

In the embodiment shown in figure 32 and 33 the transfer station 171 and vertical delivery tube 174 are rotatably supported by a bracket 177 that extends laterally from the setting tool at a location above the nose 172. In the position shown in figure 32, a rivet passage in the transfer station 171 is in register with the side port 172 of the nose 173 so that a rivet may be loaded, and in the position shown in figure 33 the transfer station 171 has been rotated through $90^0$ manually or by an appropriate actuator (not shown) to move clear of the nose 173. The latter position allows the nose 173 to extend towards the workpiece to insert the rivet. The transfer station 171 may

also be rotated to this latter position to allow access for maintenance purposes or to purge an unwanted batch of rivets in the machine.

Figures 34 to 38 show an example of the internal configuration of a transfer station of the present invention for loading a rivet into a side port of the setting tool nose. This may be used in any type of side loading transfer station including those shown in figures 30 to 33. The figures show a chronological sequence of steps for loading of a rivet into the nose.

A vertical rivet delivery tube 180 enters the transfer station housing 181 from above and to one side. Inside the housing it bends through $90^0$ into a horizontal position and then bends through approximately $90^0$ in the horizontal plane where it intersects a rivet transfer track 182 that communicates with the rivet delivery passage 183 in the nose 184 via a side port 185 in the nose 184. On the opposite side to the nose 184 a plunger 186 is disposed with its longitudinal axis aligned with the transfer track 182. A significant length of the plunger 186 has a toothed formation 187 on its upper surface to define a rack that is engaged by a rotary pinion 188 which in turn is driven by a motor 189 that extends out of the housing 181 on the opposite side to the delivery tube 180. Any rotary, linear, pivotal or cam operated actuator may be used instead of a motor. Rotation of the pinion 188 by the motor 189 causes the plunger 186 to move axially into the transfer track 182.

Adjacent and parallel to the plunger 186 there is disposed an elongate separator blade 190 having an arcuately recessed tip 191 that is designed to pass between adjacent rivets 192 emerging from the delivery tube 180. The separator blade 190 is spring biased to an extended position in which it blocks communication between the transfer track 182 and the delivery tube 180 and is retractable by a solenoid 193 (other actuators such as pneumatic may be used) that is intermediate the delivery tube 180x and the separator blade 190.

On the other side of the transfer track 182, opposite the delivery tube 180, there is an open port 194 through which dust and debris can be dissipated away from the transfer track and the nose. This port 194 also reduces air turbulence and therefore vibration or bouncing of the rivets. Above the port 194 is disposed a gate assembly

195 that is pivotally mounted on a pin 196. Movement of the gate assembly 195 is detected by an adjacent sensor 197. The gate assembly 195 comprises a support plate 198 and a gate 199 that is pivotally mounted thereon by a second pin 200. At the rear of the plate 198 adjacent the sensor 197 there is a flag 201 which operates to trigger the sensor 197. The gate assembly 195 is biased into a position in which it protrudes into the transfer track 182 by means of a torsion spring 202 one end of which bears against the rear of the gate 199 and the other end of which bears against a fixed part 203 of the housing.

In figure 34 there is shown a first rivet 204 in the vertical part of the delivery tube 180 and second and third rivets 205, 206 at the end of the delivery tube 180 in the transfer station housing 181. The foremost rivet 206 in the delivery tube 180 is in abutment with the gate 199. The next rivet 205 is one which has been supplied inadvertently. The gate assembly 195 is biased by the torsion spring 202 into the position shown and described above. At this point in time the solenoid 193 is released so that it extends the separator blade 190 under bias, the blade 190 passing in between the two rivets to a position shown in figure 35 thus preventing rivet 205 from entering the transfer track 182. The gate 199, being biased into the transfer track 182, serves to absorb the energy of the rivets that exit from the delivery tube 180 and provides support against the rivets tumbling when first entering the track 182 whilst the separator blade 190 extends. The pressure applied by the separator blade 190 on the leading rivet 206 causes the gate assembly 195 to pivot away from the transfer track 182 thereby causing the flag 201 to trigger the sensor 197 which indicates that a rivet is present and ready for a signal to start rotation of the motor 189. At this point in time the compressed air supply can be shut off and the rivet remains in this "dwell" position. The rotating pinion 188 drives the plunger 186 forwards into the transfer track 182 where its tip abuts the leading rivet 206 as shown in figure 36. The consequential movement of the rivet 206 towards the side port 185 of the nose 184 causes the rivet 206 to bear against a nipple 207 on the gate 199. Further extension of the plunger 187 causes the gate 199 to pivot clear of the transfer track 182 thereby permitting the rivet 206 to pass into the rivet delivery passage 183 of the nose 184

under the influence of the plunger 186 as illustrated in figure 37. The plunger 186 then retracts and the cycle starts again with gate assembly 195 pivoting to the position shown in figure 34 in which the flag 201 moves clear of the sensor 197 and provides a trigger to indicate that the rivet 206 has been loaded and the transfer station is ready to accept the next rivet.

The nipple 207 on the gate 199 prevents the foremost rivet 206 from advancing towards the nose of its accord during its high speed entry to the transfer station or during its dwell time in the station.

The second rivet 205 may then be used (rather than wasted) in the next cycle of the transfer station. A short air blast may be used to transfer it into abutment with the gate 199.

In an alternative embodiment rivets may be in a queue, upstream of the separator blade.

The transfer station described above ensures that rivets are loaded sequentially into the nose in a controlled fashion. Moreover, since the rivets are fed to an intermediate position outside of the nose, and offset from the side part of the nose, only one rivet at a time can be delivered to the nose and debris from the tube delivery is not directed into the nose.

Figures 39 to 43 illustrate a slightly modified version of the transfer station described above. The principal difference is that the plunger 220 has an axial through bore 221 that is connected to a source of suction pressure (not shown here but described in our British patent No. 2302833). This embodiment is intended for use in applications where the rivet setter tool has no supporting nose (as might be the case in applications where there is restricted access to the workpiece). The punch 222 (shown in figure 43) similarly has an axial bore 223 connected to a source of suction pressure (not shown). When the suction pressure is applied, the plunger 220 not only pushes the rivet 206 towards the rivet setter but also positively engages it such that it is retained on the end of the plunger 220 under suction as it extends out of the housing 181 to a centralised position under the punch 222 determined by part of the plunger that engages with the punch 222 (as shown in figures 41 and 43). The punch 222 can

either be stationary immediately above the rivet or may descend into contact with the rivet 206 to the position shown in figure 43. The suction pressure of the punch 222 is applied before the suction pressure of the plunger 220 is released so that the rivet 206 is transferred on to the end of the punch 222.

Figures 44 and 45 show modified embodiments of the rivet setter of figures 39 to 43 in which there is provided a pre-clamping member 230 around the punch 222. In the embodiment of figure 44 the pre-clamping member 230 comprises two diametrically opposed portions flanking the punch 222. In the embodiment of figure 45 the pre-clamping member 230 fully encloses the circumference of the punch 222 and a side port 231 is provided for the incoming rivet 206.

Each of the transfer stations described above in relation to figures 30 to 45 are modular and interchangeable with different stations to accommodate different sizes of rivet. The transfer stations are separate to the nose of the setting tool thereby ensuring the nose design can be of minimum size and complexity.

The individual modules can be configured in a variety of ways to suit the application thereby reducing the need to redesign the setting tool. In particular the transfer station may be attached to and moveable with the nose; attached to the setting tool but not moveable with the nose; attached to the tool, not moveable with the nose but retractable clear of the nose (as shown in figures 30 to 33); or even may be hand-held by an operator in applications where access to the nose is limited.

Figures 46 to 53 show a transfer station that is used to feed rivets to the end of the rivet setter nose (i.e. into the end of the nose from which it is discharged during the riveting operation). The figures show the chronological sequence for loading of the rivet.

The rivet setter 250 is of conventional design and is therefore not described in detail here except in so far as is relevant to the interaction with the transfer station which is the inventive aspect of this embodiment. The transfer station 251 is connected to the rivet setter 250 by a bracket 252 disposed above the nose 253 and comprises a lever 254 that is pivotally connected at one end to the bracket 252 by a first pin 255 and at the other end by a second pin 256 to the end of a piston 257 of a

pneumatic or hydraulic cylinder 258 (it is to be appreciated that other suitable actuators may be used instead). A torsion spring 259 is supported around pin 255 and serves to bias the lever 254 in a clockwise direction against a rigid rivet feeder tube 260 that releasably connects co-axially to the end of a rivet delivery tube or magazine (shown only in figure 46) and is secured to the lever 254. The free end of the feeder tube 260 bends towards the nose 253 of the rivet setter 251. A delivery arm 261 is pivotally connected to a rearwardly extending lug 262 of the feeder tube 260 and extends parallel to the end portion thereof, towards the nose, in a slot on the underside of the feeder tube 260. The free end of the delivery arm 261 has a small upstanding projection 263 that is designed, in use, to engage with a rivet 264. The opposite end of the delivery arm 261 is connected to the lever 254 by connecting rod 265.

In use, rivets are fed under compressed air down the delivery tube and into the feeder tube 260 of the transfer station 251 whereupon they are transferred singly into the end of a rivet delivery passage 266 in the nose 253 as will be described below. When the rivet 264 is present in the end of the nose 253 (as shown in figure 46), the nose of the setting tool 250 is indexed towards the workpiece (figure 47) and a punch 267 in the delivery passage 266 extends downwardly to force the rivet 264 into the workpiece (figure 48) as is well known. The rivet 264 is releasably retained in the end of the rivet delivery passage 266 by any suitable retention means (e.g. vacuum, Velcro. adhesive, spring loaded balls etc.) such as those described in our UK Patent No. 2302833.

As the punch 267 is indexing towards the workpiece (not shown in the figures), further rivets are delivered to the feeder tube 260 from any appropriate feeder mechanism as described above. Several rivets 268 are shown in the feeder tube 260 of figure 47. The leading rivet 264 abuts the upstanding projection 263 (described in detail below) on the delivery arm 261 where it is retained until the nose 253 is fully retracted and ready to be loaded (as shown in figure 49). The piston 257 in the cylinder 258 is then extended so as to pivot the lever 254 and feeder tube 260 about pin 255. This action pivots the feeder tube 260 towards the end of the nose 253 until

the leading rivet 264 retained at the end of the feeder tube 260 is presented to the end of the delivery passage 266 in the nose 253 as shown in figure 50. Further extension of the piston 258 serves to pivot the delivery arm 261 upwards and to tension the torsion spring 259 (via the connecting rod 265 and lever 254) through a small angle so that it pushes the rivet 264 into the end of the delivery passage 266 where it is retained by the retention means (see figure 51). The gripping force of the retention means (not shown) is designed to be greater than that provided by the projection 263 in the delivery arm 261 so that transfer of the rivet 264 is smooth and unhindered. The piston 258 is then retracted slightly to pivot the delivery arm 261 out of engagement with the rivet 264 (figure 52) and full retraction moves the transfer station clear of the nose 253 (figure 53). The nose 253 then has a clear path to extend relative to the transfer station 261 (figure 47) and insert the rivet 264 into the workpiece (figure 48). A sensor (not shown) may be provided at the end of the feeder tube 260 or the delivery arm 261 to detect the presence of a rivet 264 before loading it into the nose 253.

The above arrangement can be used with any length of nose and stroke length of the rivet setter. The rivet transfer station, being moveable away from the nose, does not risk fouling the riveting process and does not have to be designed to withstand the clamping and insertion forces associated with the riveting process. Moreover, by eliminating the need for a side entry port the cross section of the nose is not weakened. By moving the delivery tube/feeder tube combination with the transfer station only a single transfer movement is required to transfer the rivet to the delivery passage in the nose thereby eliminating the need for a separate mechanism to transfer the rivet from the end of the delivery tube a mechanism that loads the nose.

In a modified embodiment of the above, the upstanding projection 263 on the delivery arm 261 is supplemented with a pair of spring biased fingers 280 mounted on the feeder tube 260 as shown in figures 54 a, b, c, d. The fingers 280 extend along the feeder tube 260 and are biased together by compression springs 281 so that tips 282 of the fingers 280 are nearly in contact. The tips 282 of the fingers 280 trap an incoming rivet 264 and retain the rivet 264 in place until the upward movement of the delivery

arm 261 separates the fingers 280 and directs it into the nose 253. The fingers 280 are chamfered (at 283) so as to receive the arm 261. The compression springs 281 of the fingers 280 serve to absorb the momentum of the rivet 264 without any impact damage.

The upstanding projection 263 is mounted on a rounded support 284 that is received in a complementary recess 285 such that it is able to be tilted so as to accommodate both short and long stem rivets. The spring plate 286 and keeper plate 287 retain the projection 263 in place as shown in figures 54c and 54d.

Figures 55 to 58 show an embodiment of a transfer station that rotates a rivet through $90^0$ thereby obviating the need to incorporate a bend in the delivery tube (the disadvantages of which were described earlier).

A rivet delivery tube 300 enters the transfer station 301 vertically and is directed into the nose N (shown only in figure 58) in the direction indicated by arrow X (figure 55). Immediately below the tube exit there is a rivet retainer 302 that has a U-shaped seat 303 for receiving a rivet 304 egressing from the exit of the delivery tube 300. The retainer 302 is pivotally mounted on a pin 305 that extends between opposed slots 306 in side walls 307 of the transfer station 301. Immediately behind the retainer 302 is an axially reciprocating plunger 308 shown retracted in figure 55 and extended in figures 57 and 58. An interference block 309 having an upwardly facing cam surface 310 is disposed below a portion of the slots 306 nearest the nose.

In operation, a rivet 304 egressing from the delivery tube 300 exit falls into the seat 303 of the rivet retainer 302 disposed immediately below (figure 55). The plunger (which is spring biased) 308 extends forward into contact with the rivet retainer 302 so that pin 305 slides in the slots 306 and the retainer 302 is moved towards the nose N in the direction of arrow X. In this position the plunger 308 also serves to close the exit of the delivery tube 300. As the pin 305 moves along the slots 306 it engages the cam surface 310 and the resulting friction contact causes it (and therefore the rivet retainer 302 and the rivet 304) to rotate about its longitudinal axis through $90^0$ (figure 57). The rivet 304 is then in the correct orientation to enter a delivery passage 312 in the nose N. When the rivet retainer 302 reaches the end of the slots 306, continued

extension of the plunger 308 moves the rivet 304 out of the seat 303 and into the delivery passage 312 via a side port 313 in the nose N (figure 58). On retraction of the plunger 308 the retainer 302 pivots back through $90^0$.

It is to be understood that the delivery tube may be replaced with a fixed or removable rivet magazine as described earlier. The rivet may be transferred to the rivet retainer by falling under gravity or a release mechanism such as an escapement wheel as described earlier, or a separator blade or rotary auger.

An alternative embodiment of a transfer station for rotating the rivet through $90^0$ is illustrated in figures 59 and 60. Rivets are again loaded singly into the transfer station 400 via a vertical delivery tube 401 or magazine and are received in a rivet retainer disposed below the tube exit. The station has a transfer mechanism comprising a plunger and an elongate pusher arm assembly 402, 403 that are slidable together within a cylindrical housing 404 The assembly is moved by an actuator 405 disposed at the end of the housing 404 opposite the nose N. The plunger 402 is cylindrical with a helical slot 406 along part of its length that receives a pin 407 fixed in the housing 404, and is rotatably mounted in the housing 404. At the free end of the assembly 402, 403 there is a spring-loaded pivotal retaining arm 408 which is biased towards the end of the plunger 402 so as to retain a rivet 409 securely such that its head abuts against the outside diameter of the end of the plunger 402 as shown in figure 60.

In operation, a rivet 409 egressing from the delivery tube 401 is received by the retaining arm 408. Axial movement of the assembly 402, 403 by the actuator 405 moves the rivet 409 towards the nose N in the direction of arrow Y thereby separating it from the delivery tube 401. Thereafter, further rectilinear movement of the assembly 402, 403 causes it to rotate through $90^0$ relative to the housing 404 by virtue of the slot 406 in the plunger 402 moving over the fixed pin 407. After the rotational movement is complete the pusher arm 403 is extended relative to the plunger 402 so as to move the rivet 409 beyond the retaining arm 408 and into a delivery passage 410 of the nose N via a side port 411.

As an alternative to the embodiments of figures 55 to 60, the designs shown in figures 21 to 25a may be used to turn a rivet through $90^0$. The rotary escapement wheel 88 can be disposed at the end of a blow tube adjacent the setting tool nose or may be used as a release mechanism at the feeder end to release rivets from a container.

Figures 61 and 62 show part of a transfer station that has two incoming rivet delivery tubes so that rivets from two different sources may be provided to a single transfer station. This enables rivets of two different types to be supplied to the nose or a second back-up supply of rivets to be provided.

The inlet tubes 500, 501 in the embodiment shown are approximately at right angles and meet adjacent the setter tool nose N. At the intersection of the tubes 500, 501 there is disposed a rotary gate 502 that is slotted (at 502a) to receive a single rivet. An outlet track 503 interconnects the rotary gate 502 with a delivery passage 504 in the nose N. Intermediate the two delivery tubes 500, 501, and adjacent the gate 502, is a reciprocal pusher arm 505.

The gate 502 is moveable by a rotary actuator (not shown) between three positions. In a first position the slot 502a is in alignment with the first inlet delivery tube 500 (shown in figure 61) and in the second position (not shown) it is in alignment with the second delivery tube. In these positions the gate 502 is able to receive an incoming rivet 506 (shown in dotted line). Side walls of the slit 502a have a resilient lining (such as spring steel strips 508 as shown in the embodiments of figures 61 and 62) that releasably grips the rivet 506 so that it is retained by the gate 502. In a third position, intermediate the first two portions, the slot 502a is in alignment with the outlet track 503. In this position subsequent incoming rivets 507 are prevented from entering the gate 502 and the pusher arm 505 is indexed forward to force the rivet 505 out of the gate 502 and into the nose N (see figure 62). Rotation of the gate 502 may serve to separate the collected rivet from the following rivets. The gate 502 may be rotated to the intermediate third position once it has received the incoming rivet prior to the supply of pressurised air being switched off.

## CLAIMS

1. A method for controlling the continuous flow of fasteners in a fastening machine wherein the fasteners are presented to the fastening machine in a succession of sealed containers that each bear manufacturing batch information and fastener identification data, the containers being used in a predetermined order relating to the manufacturing batch information, the fasteners being released from the container only when they have been secured to a feeder assembly of the machine and the elements from the previous container have been discharged from the feeder assembly, the manufacturing batch information and fastener identification data being read and recorded by the machine before the fasteners are released.

2. A method according to claim 1, wherein the container is automatically opened by the machine when secured to the feeder assembly and the elements from the previous container have been discharged.

3. A method according to claim 1 or 2, wherein the read fastener identification data is compared to stored data representing the desired fastener and if they do not match the fasteners in that container are discarded.

4. A method according to claim 1, 2, or 3 wherein the rate of use of the fasteners is measured and new containers of fasteners are automatically loaded and/or ordered as appropriate.

5. A method according to any preceding claim wherein there is provided automatic means for purging all fasteners from the machine and means for counting the purged fasteners.

6. A feeder device for a fastener machine comprising a hopper having at least one aperture into which a sealed container of fasteners is releasably secured, a gate which is moveable relative to the hopper between positions which open and close the aperture and a reservoir into which released fasteners are dispensed, wherein the container has a frangible seal that is broken when the feeder device is satisfied that the contents are correct so as to release the fasteners, the gate moving to the open position to pass the fasteners to the reservoir.

7. A feeder device according to claim 6, wherein the container has a plurality of notches that identify the contents and a checking device is provided to detect the presence of the notches to ensure the contents of the container are correct.

8. A feeder device according to claim 6 or 7, wherein the gate is rotatable relative to the hopper between the open and closed positions.

9. A feeder device according to claims 6, 7 or 8, wherein the container has a lip by which it is releasably securable under an edge of the aperture.

10. A feeder device for a fastening machine comprising a support on which are mounted a plurality of containers each containing fasteners in vertical array, and a release mechanism that is moveable relative to an underside of the support, the release mechanism comprising a carriage captively fitted to the support and a chamber for receiving at least one fastener from a container, an actuator for directing the fastener out of the carriage into a delivery tube and release means for releasing a fastener from the container.

11. A feeder device according to claim 10, wherein the release mechanism further comprises a guide element that engages a complementary guide element on the support so that its movement under the support is along a predetermined path.

12. A feeder mechanism according to claims 10 or 11, wherein the fasteners are released from the container into the carriage under gravity.

13. A feeder mechanism according to claim 12, wherein the release means is a pusher arm that pushes the released fastener to a position adjacent an exit aperture.

14. A feeder mechanism according to any one of claims 10 to 13, wherein the support is inclined to the horizontal so that the carriage is moveable in at least one direction under gravity.

15. A feeder device for a fastener machine comprising a tray defining a plurality of channels in which rivets are received, a release gate with an aperture, the gate being removable relative to the tray so as to bring the aperture into register with a selected channel, and means for extracting the fastener from the channel.

16. A feeder device for a fastener machine comprising a flexible sealed bag defining a plurality of sealed channels containing fasteners, a blade for severing a selected channel so as to release the fasteners and a reservoir into which the fasteners are released.

17. A feeder device according to claim 16, further comprising a rotary slotted drum over which the bag is wound, the blade being radially moveable into a slot to sever the bag and release the fasteners from a selected channel.

18. A setting tool for a fastening machine comprising a nose piece with a fastener delivery passage therein, a magazine housing a plurality of fasteners and a transfer station for transferring a fastener from the magazine to the fastener delivery passage, the magazine comprising at least one column for housing aligned fasteners, an inlet to the column for loading fasteners, and an outlet from the column for feeding the transfer station.

19. A setting tool according to claim 18, wherein the magazine is loaded in-situ with the inlet being connected to a fastener delivery tube.

20. A setting tool according to claim 19, wherein the magazine is releasably connected to the setting tool and is loaded remotely.

21. A fastener delivery tube for interconnecting a setting tool to a source of fasteners, the tube having an internal passage through which fasteners may pass and at least one wear resistant strip that projects into the passage to contact the fastener.

22. A fastener delivery tube according to claim 21, wherein the wear resistant strip is releasably secured to a wall of the tube.

23. A delivery tube according to claim 21 or 22 wherein the walls of the tube are separable and interchangeable.

24. A delivery tube according to claims 21, 22 or 23, wherein tube comprises two portions that are interconnected by a hinge, so that the tube can be hingedly opened to expose the passage.

25. A delivery tube according to any one of claims 21 to 23, wherein the tube comprises two separable portions that each have at least one flange, flanges of the two portions being secured together by a releasable fastener.

26. A delivery tube according to claim 25, wherein the releasable fastener forms part of a support frame in which the tube is supported.

27. A delivery tube according to any one of claims 21 to 26, wherein the delivery tube has a second passage in which service cables are housed.

28. A fastener machine comprising a supply of fasteners, a setting tool and at least one delivery tube according to any one of claims 23 to 27 in which fasteners are transported between the supply and the setting tool.

29. A fastener machine comprising a setter tool having a nose with a fastener delivery passage therein, a fastener delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage, a transfer device attached to one end of the delivery tube and moveable relative to the nose, a stop member at the end of the delivery tube for stopping a delivered fastener and an actuator for moving the transfer device between a first position in which an exit of the station is adjacent to the nose so that a delivered fastener at the stop member is inserted into the delivery passage and a second position in which it is clear of the nose so as to permit the nose to move towards a workpiece to insert a loaded fastener.

30. A fastener machine according to claim 29, wherein the transfer device is pivotally mounted relative to the nose, the actuator pivots the transfer device into a first position in which the end of the delivery tube is adjacent the nose.

31. A fastener machine according to claim 30, wherein the fastener is inserted into the delivery passage via a side aperture in the nose.

32. A fastener machine according to claim 30, wherein the fastener is inserted into an end of the delivery passage where it is held by releasable retaining means.

33. A fastener machine according to claim 32, wherein an arm is connected to the delivery tube and is moveable relative thereto to move the fastener from the stop member into the releasable retaining means.

34. A fastener machine according to claim 32 or 33, wherein the stop member is in the form of a pair of spring-loaded fingers.

35. A fastener machine according to claim 29, wherein transfer device is rotatably mounted relative to the nose, and the actuator rotates the transfer device between a first position in which the end of the delivery tube is adjacent to the nose so that a delivered fastener at the stop member is inserted into the delivery passage and a second position in which it is clear of the nose so as to permit the nose to move towards a workpiece to insert a loaded fastener.

36. A fastener machine comprising a setter tool having an actuator reciprocal along a path to drive a fastener into a workpiece, a fastener delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage and a transfer device between an end of the delivery tube and the actuator, the transfer device comprising an inlet passage contiguous with the end of the delivery tube and an exit from the transfer station, the inlet passage not been aligned with the exit and a gate intermediate the inlet passage and the exit, the gate being moveable between a closed position in which it prevents movement of a fastener out of the inlet passage and an open position in which it permits a fastener to pass to the transfer station exit.

37. A fastener machine according to claim 36, wherein the gate is resiliently biased so as to absorb momentum of an incoming fastener.

38. A fastener machine according to claim 36 or 37, wherein there is provided a fastener separator for selecting a single fastener from said end of the delivery tube and a transfer member for directing the selected fastener out of the exit into the path of the actuator when the sensor is triggered, wherein operation of the fastener separator opens the gate to permit the selected fastener to be directed out of the exit by the transfer member and triggers the sensor.

39. A fastener machine according to claim 38, wherein the operation of the fastener separator traps the selected fastener between the separator and the gate and causes the gate to open.

40. A fastener machine according to claim 38 or 39, wherein the fastener separator is elongate and axially moveable in the transfer station towards and away from the end of the delivery tube.

41. A fastener machine according to claim 39 or 40, wherein the gate is pivotally mounted on a support member, the gate being biased to the closed position where it projects into a path of the selected fastener.

42. A fastener machine according to claim 41, wherein the support member is pivotally mounted in the transfer station and operates the sensor.

43. A fastener machine according to any one of claims 36 to 42, wherein the transfer member has an axial through passage connected to a source of suction pressure so that the selected fastener can be retained on the transfer member by suction pressure.

44. A fastener machine according to any one of claims 36 to 43, wherein the actuator has an axial through passage connected to a source of suction pressure and has no surrounding nose.

45. A delivery tube comprising at least first and second inlet branches connected to a single outlet branch, and a gate being disposed between the inlet and outlet and being operable to close communication between one of the inlet branches and the outlet branch.

46. A delivery tube according to claim 45, wherein the gate is pivotally mounted in the tube and is operable to close communication between the first inlet and the outlet branch by being struck by a fastener travelling along a second inlet branch.

47. A fastener machine having at least two supplies of fasteners and a setting tool interconnected by a delivery tube according to claim 45 or 46.

48. A fastener machine comprising a setter tool having a nose with a fastener delivery passage therein, a fastener delivery tube to enable fasteners to be transferred from a fastener supply to the fastener delivery passage, a transfer device disposed between one end of the delivery tube and the nose and defining a transfer path, the transfer device having a rotation device for rotating the fastener through substantially a right angle so that it is correctly oriented for entry into the fastener delivery passage, the rotation device comprising a carriage that is moveable along the transfer path toward the fastener delivery passage and is designed to receive a fastener from the delivery tube and a cam surface that causes the carriage to rotate through a right angle as it moves align the transfer path, and a plunger for moving the rotated fastener out of the carriage into the fastener delivery passage.

49. A fastener machine according to claim 48, wherein the carriage further comprises a fastener support pivotally mounted on a pivot member that is moveable in a slot defined along the transfer path.

50. A fastener machine according to claim 49, wherein the cam surface is defined on an interference block disposed in the transfer path of the carriage such that the pivot member rotate when it slides over the surface.

51. A fastener machine according to claim 48, wherein the carriage further comprises a rotary element having a helical cam surface that moves over a fixed pin on the transfer station so that axial movement of the carriage also causes it to rotate.

# ABSTRACT

TITLE

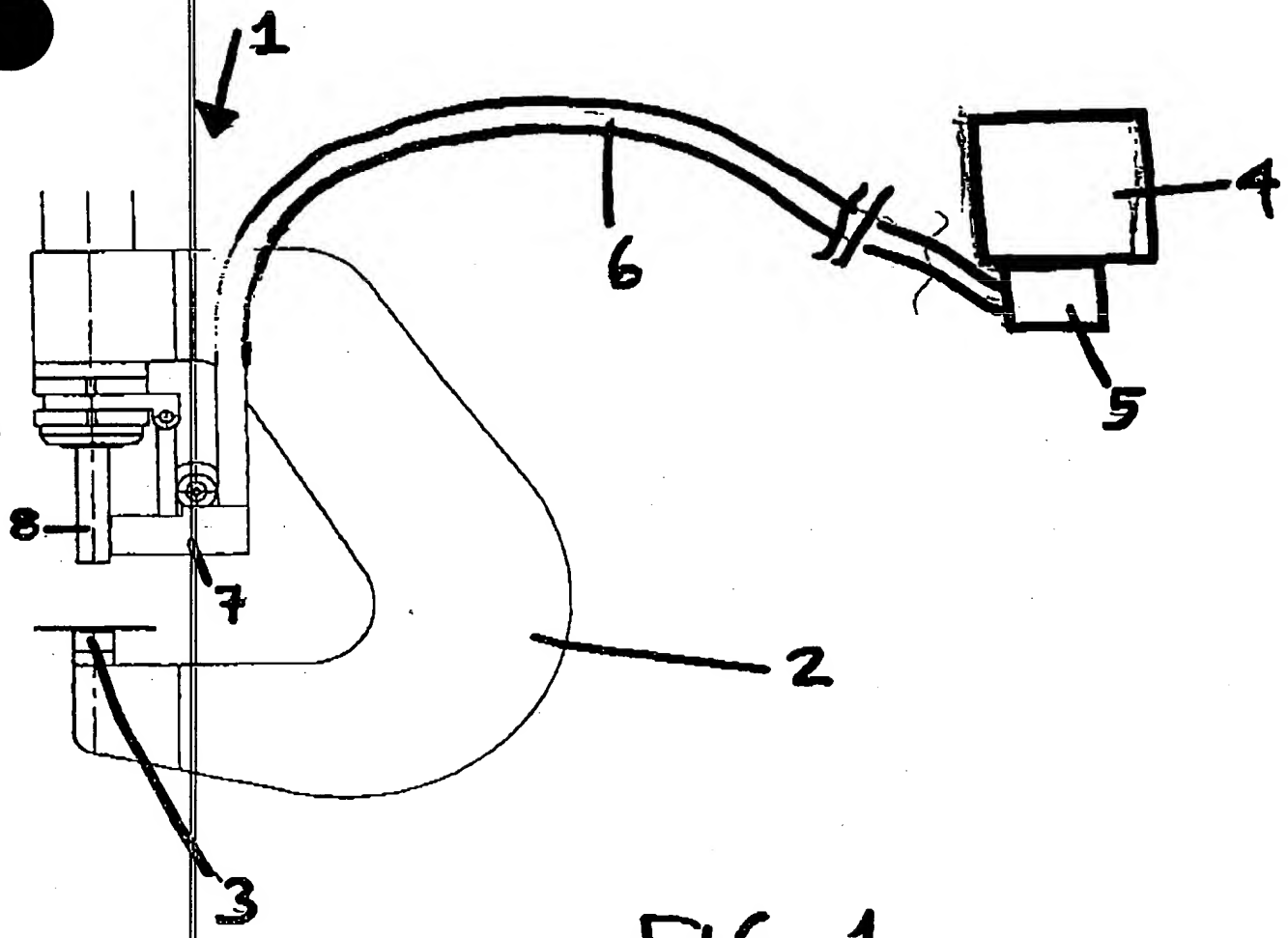



FIG 1

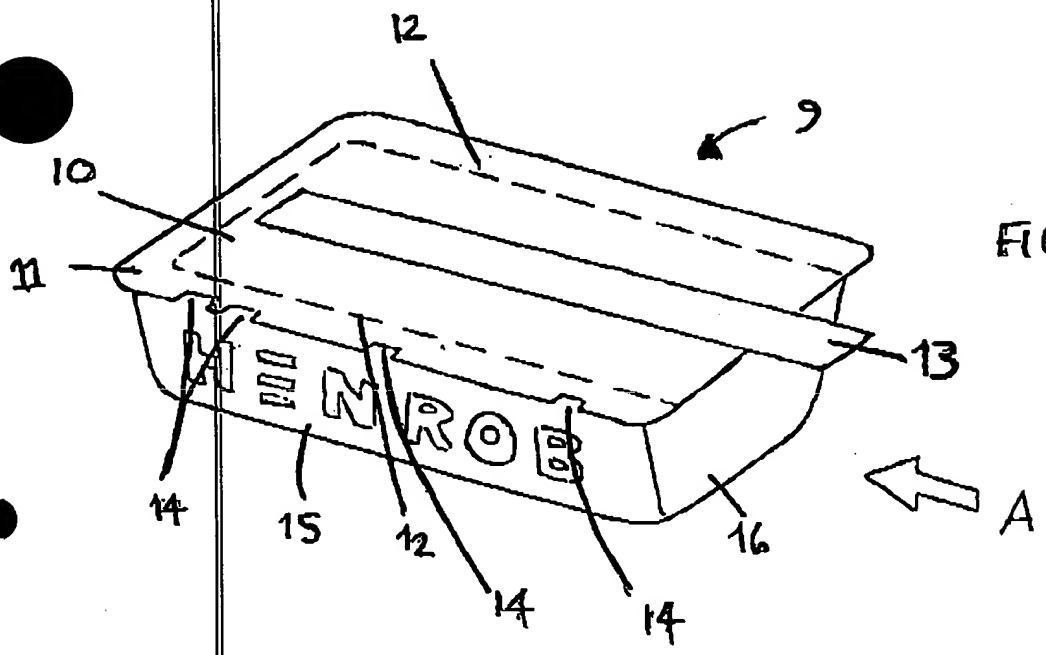



FIG 2

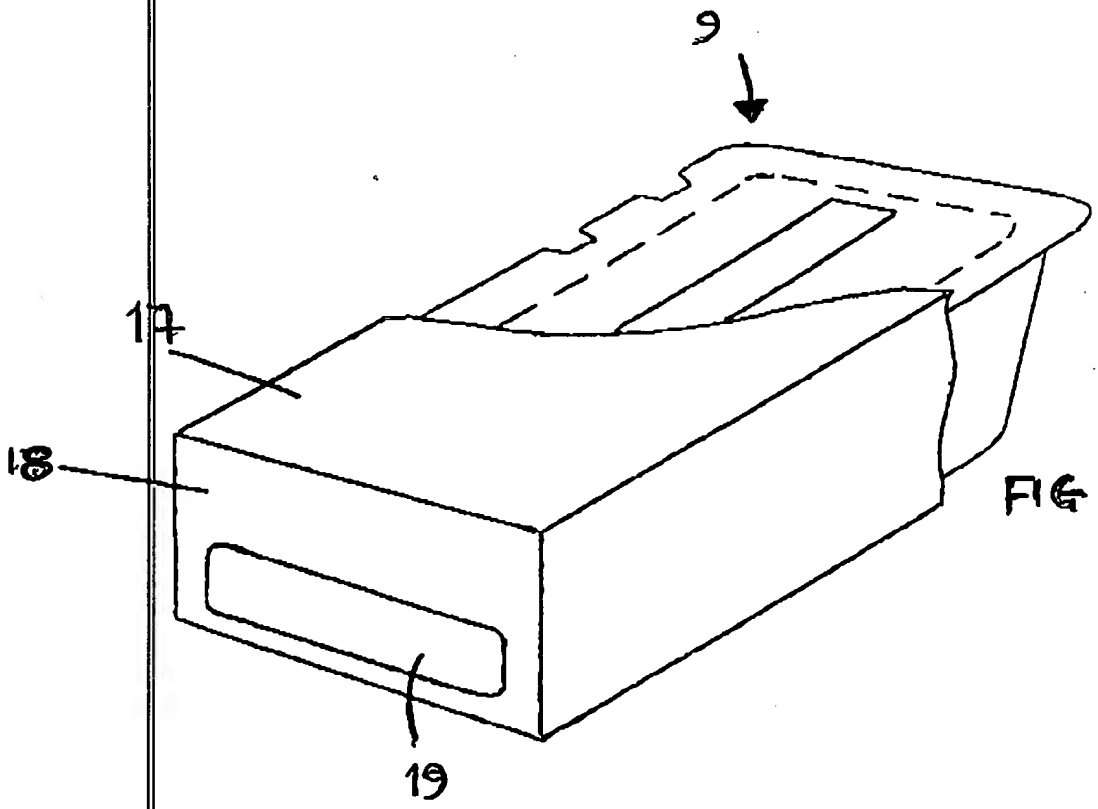



FIG 3

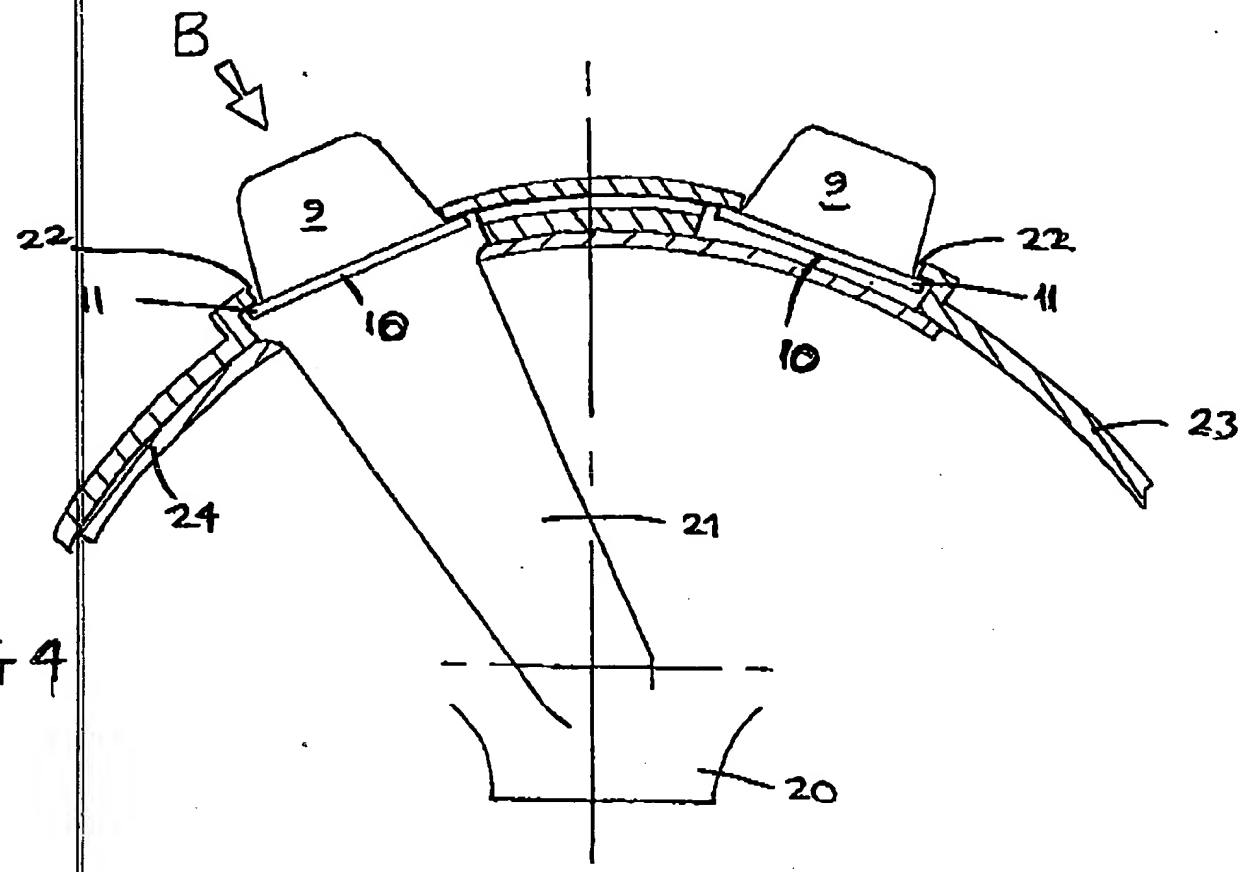
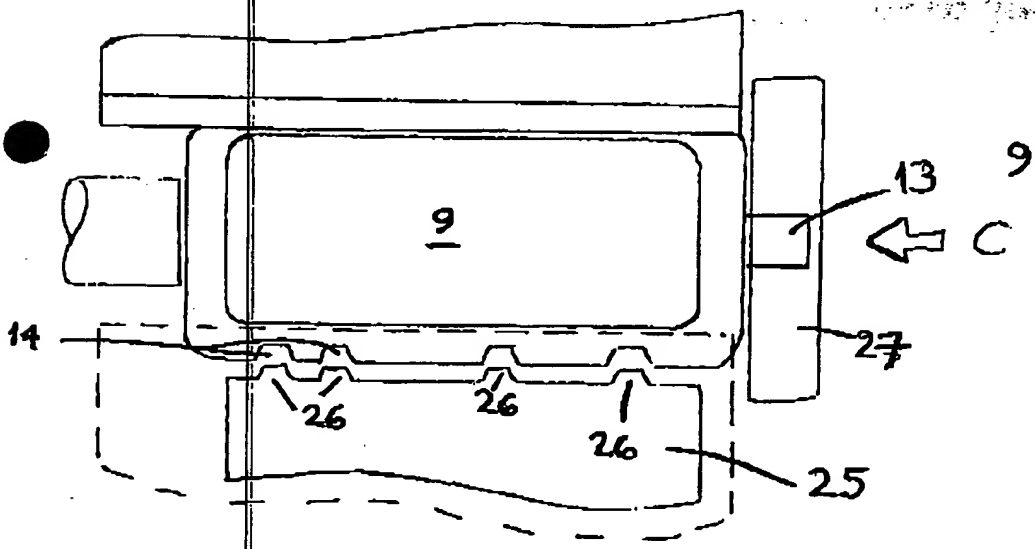
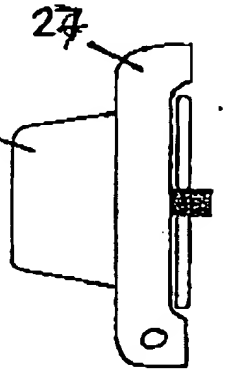



FIG 4




VIEW ON B

FIG 5




VIEW ON C

FIG 6

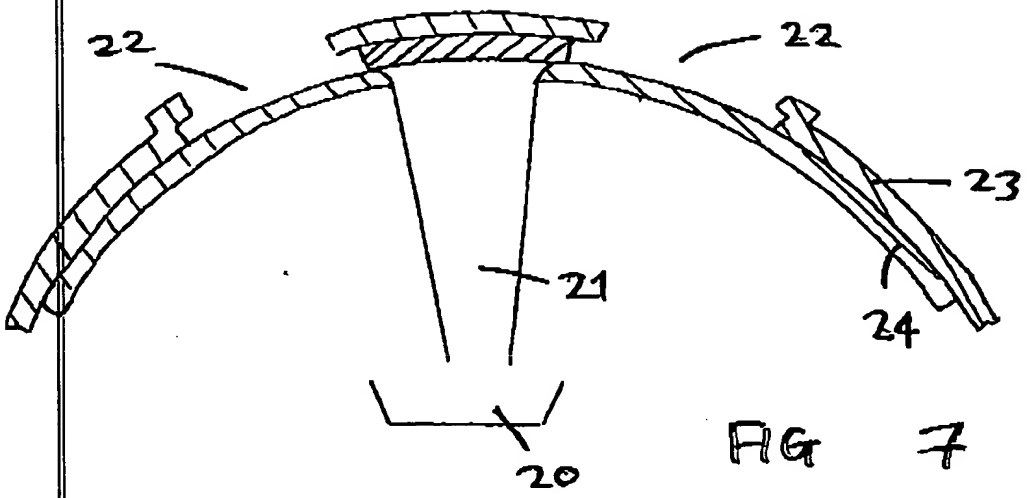



FIG 7

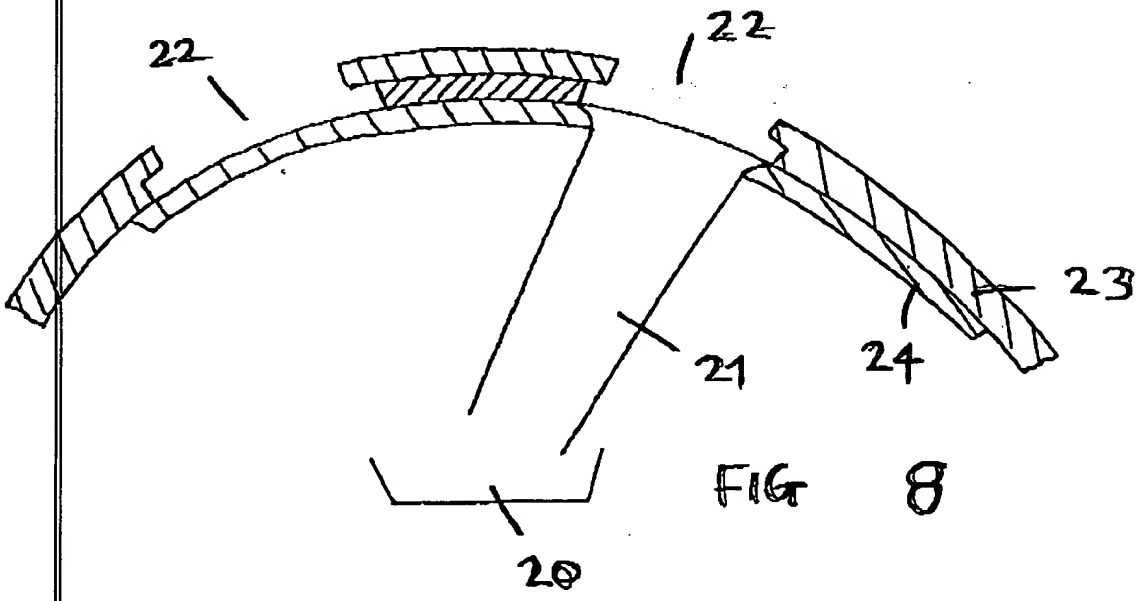



FIG 8

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FIG. 11

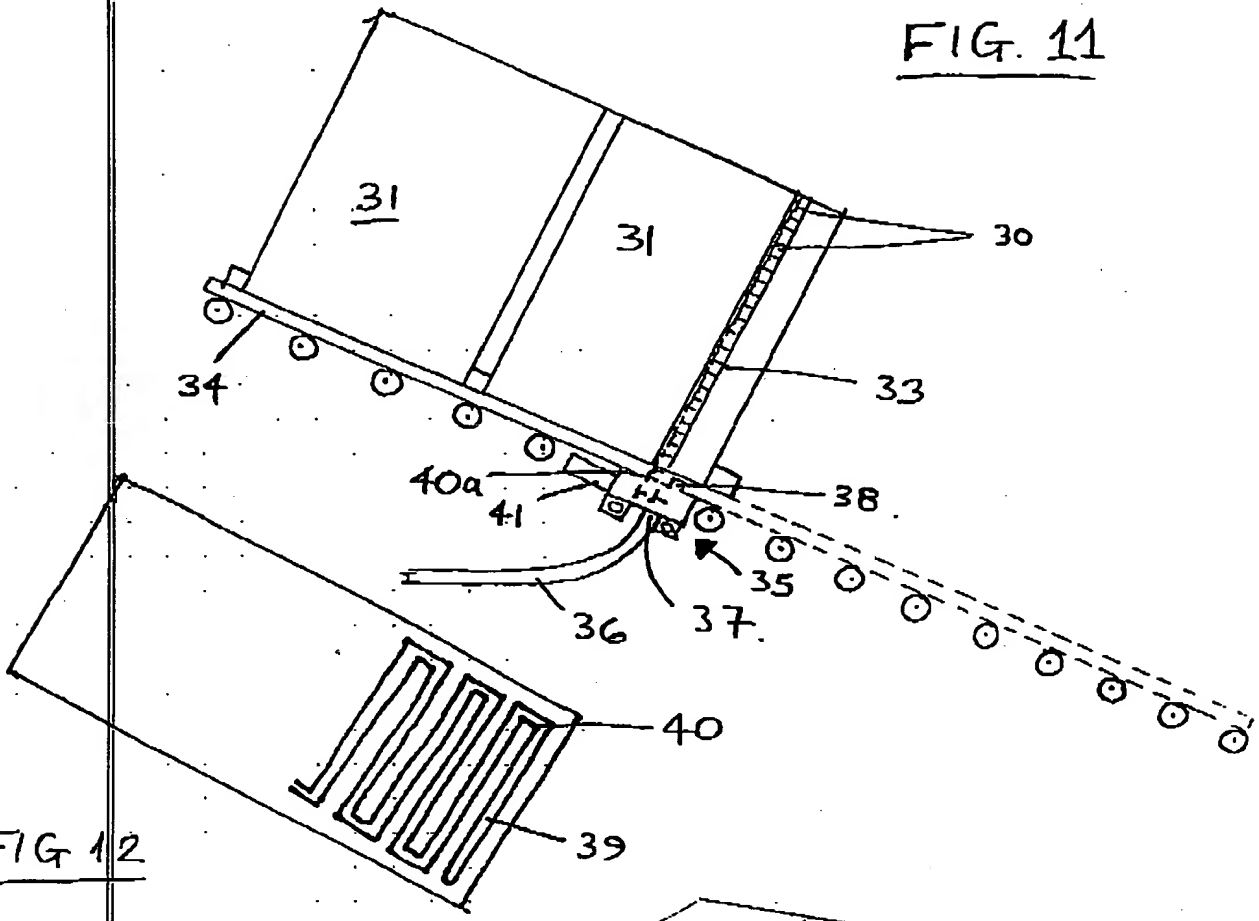
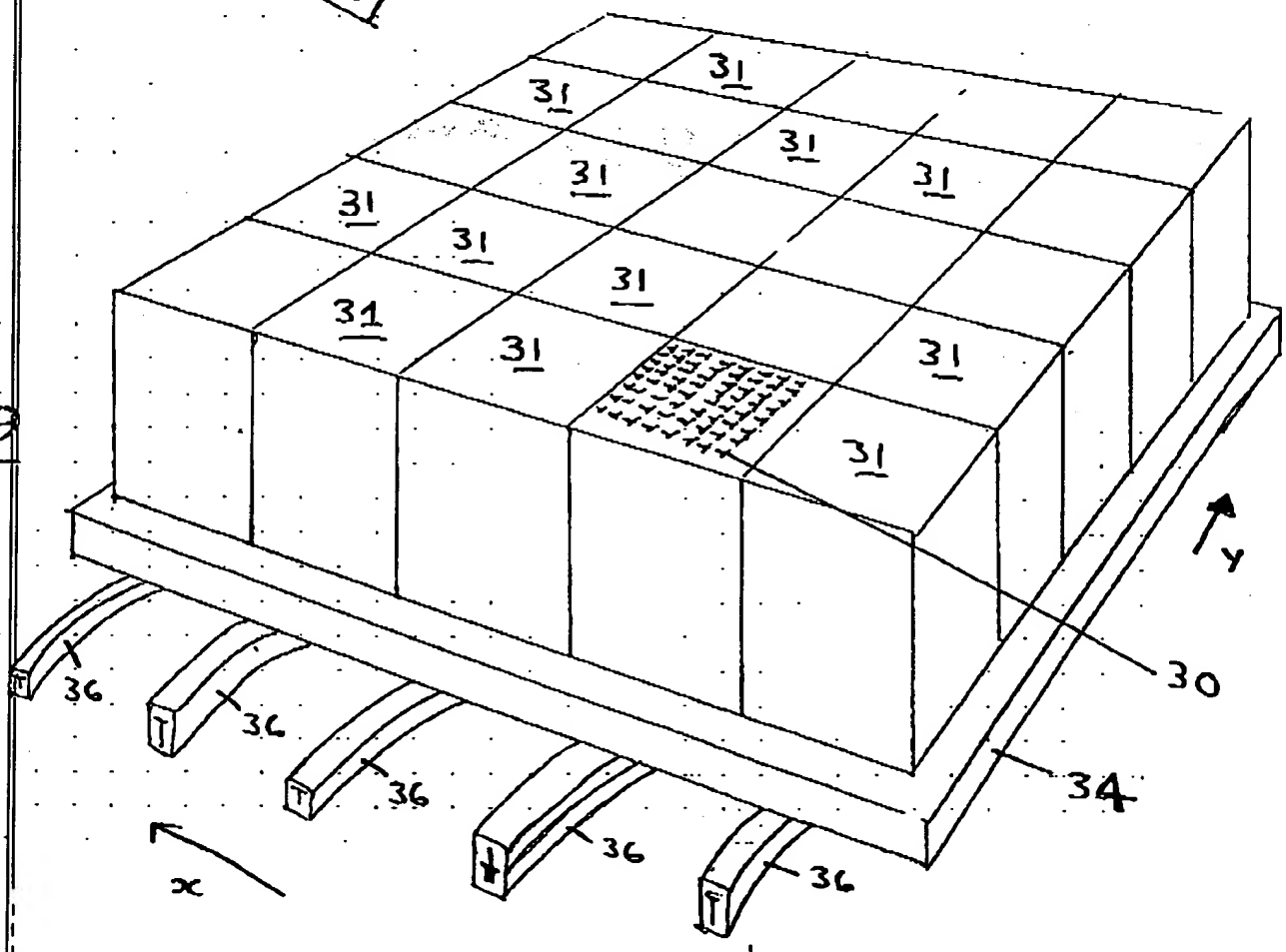



FIG 12

FIG 9



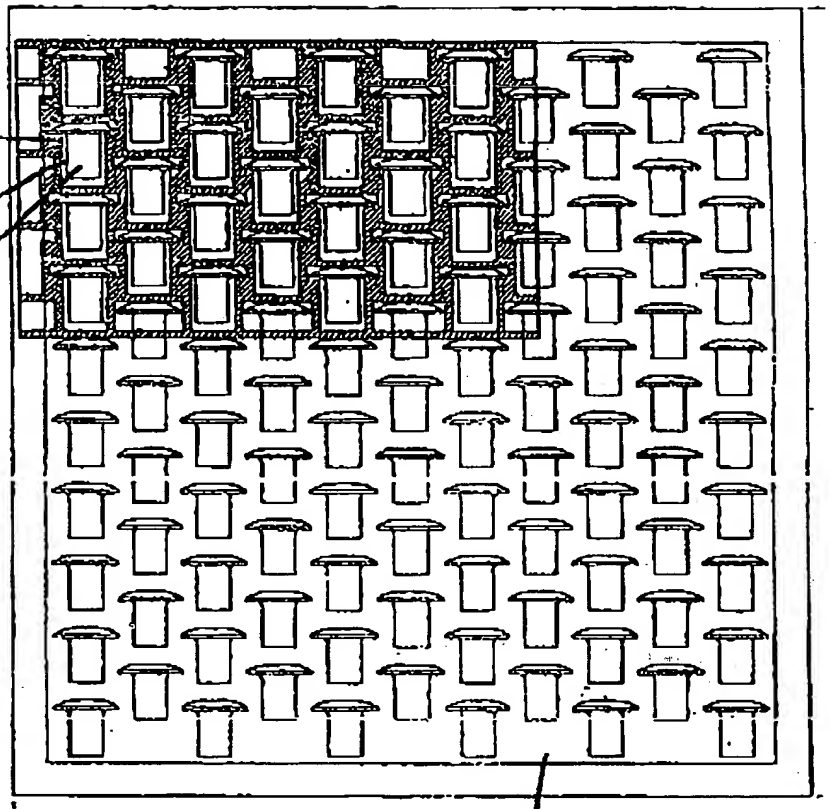



FIG 10.

FIG 13.

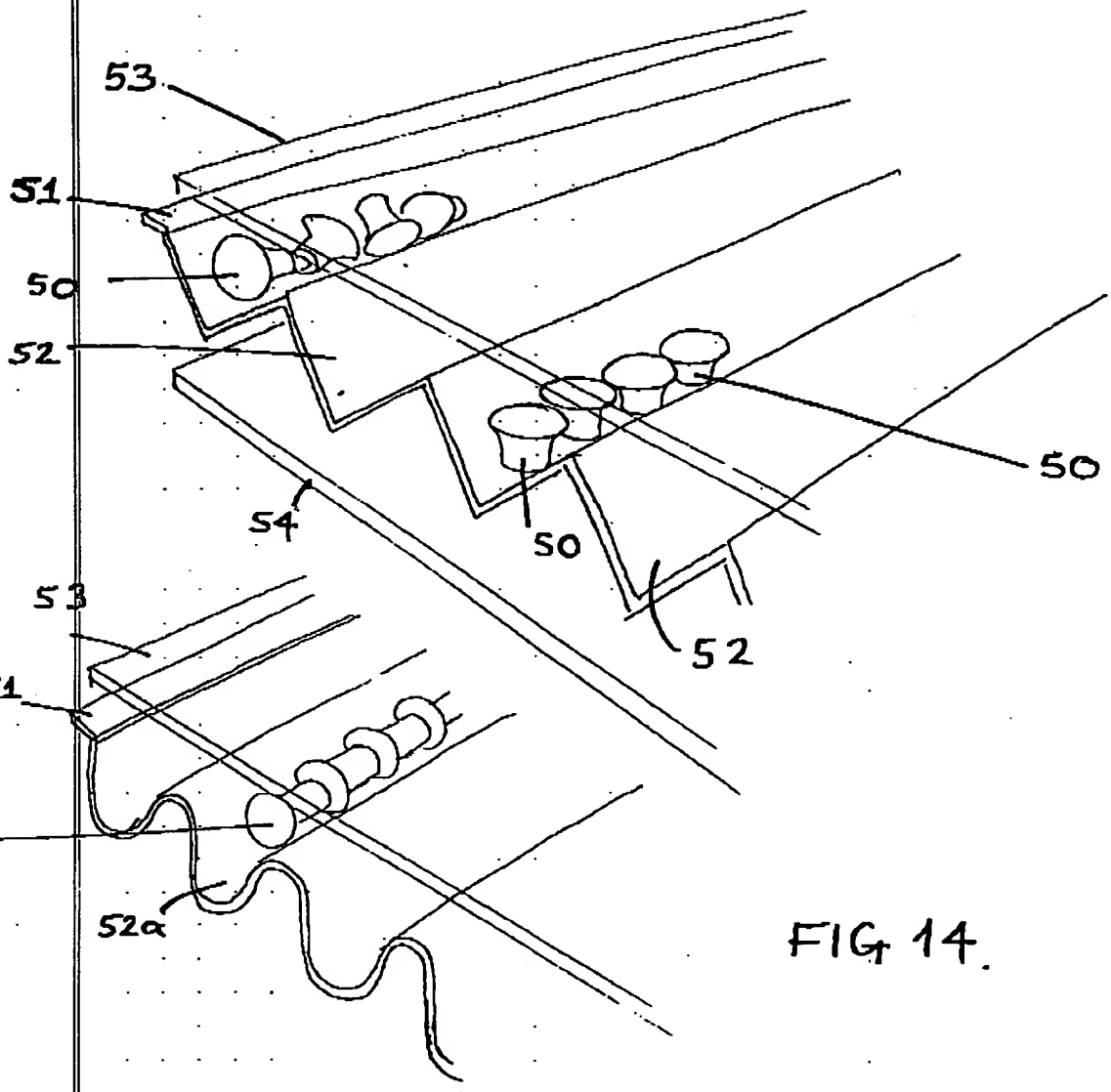
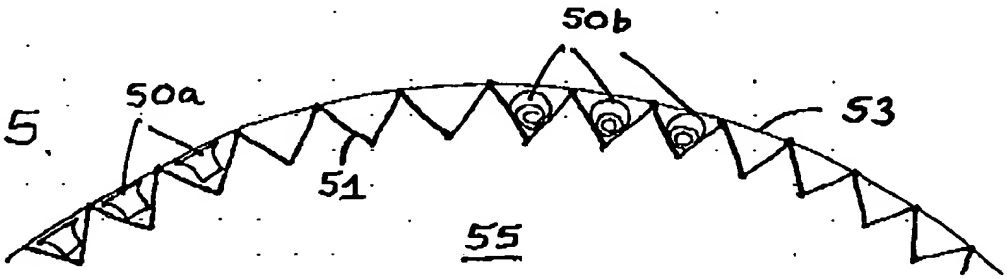



FIG 14.

FIG 15.



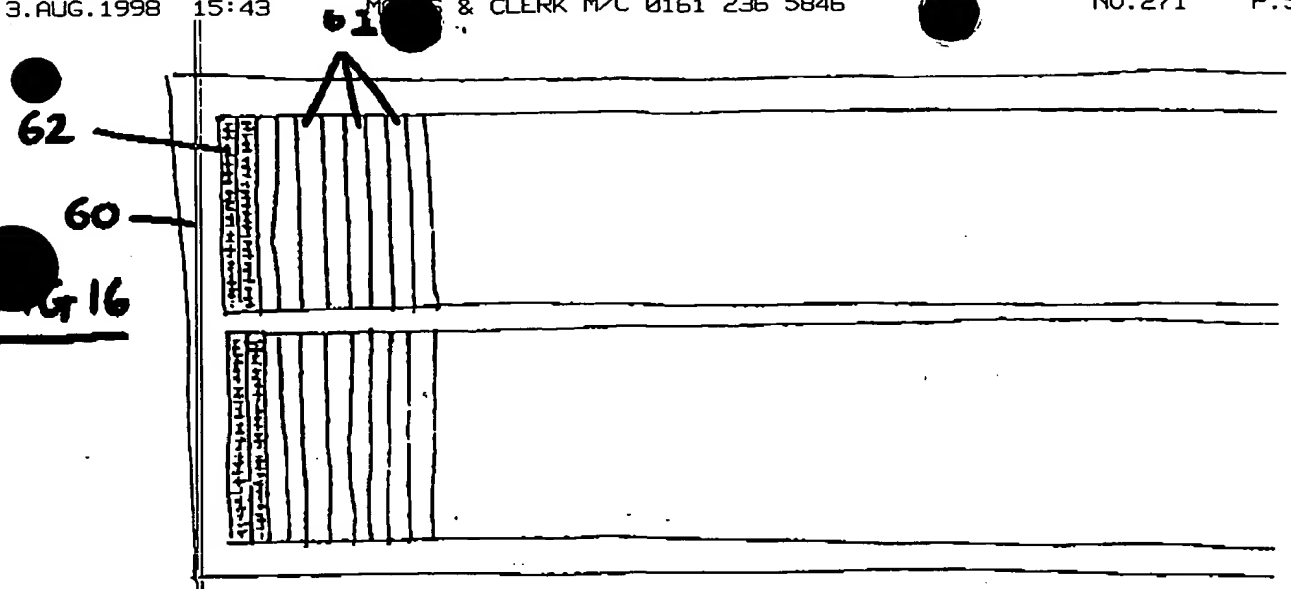



FIG 16

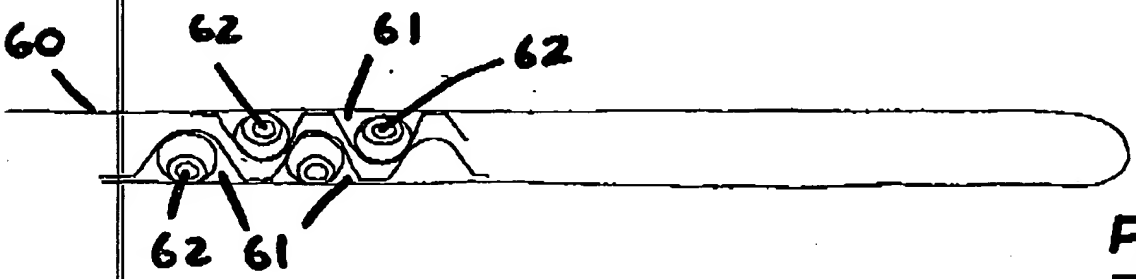



FIG.17

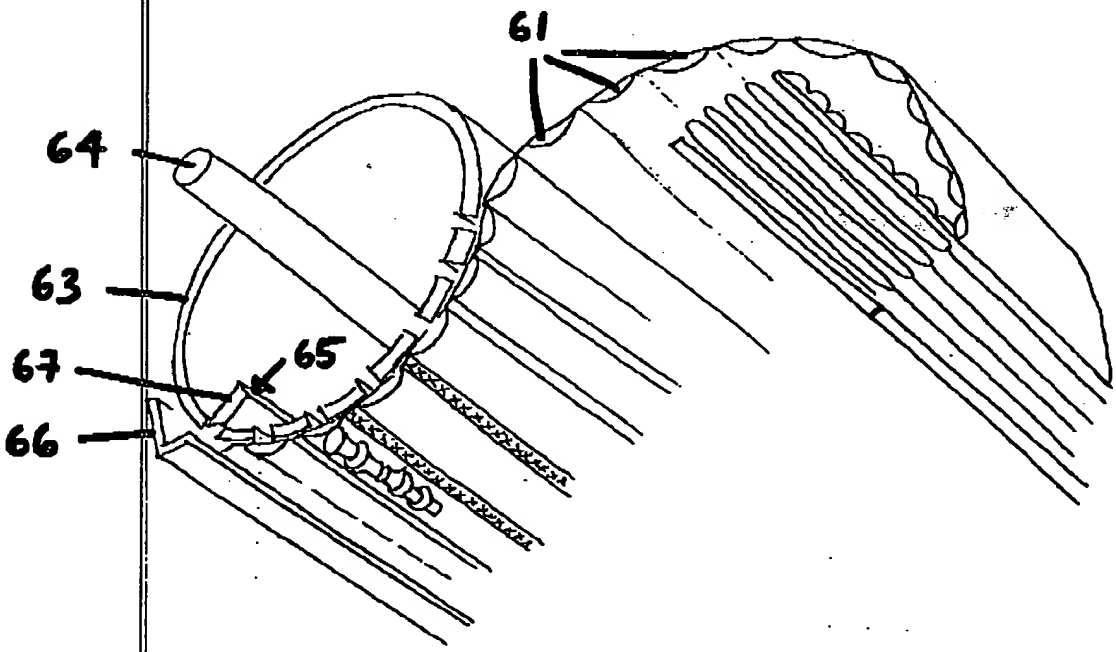



FIG. 18

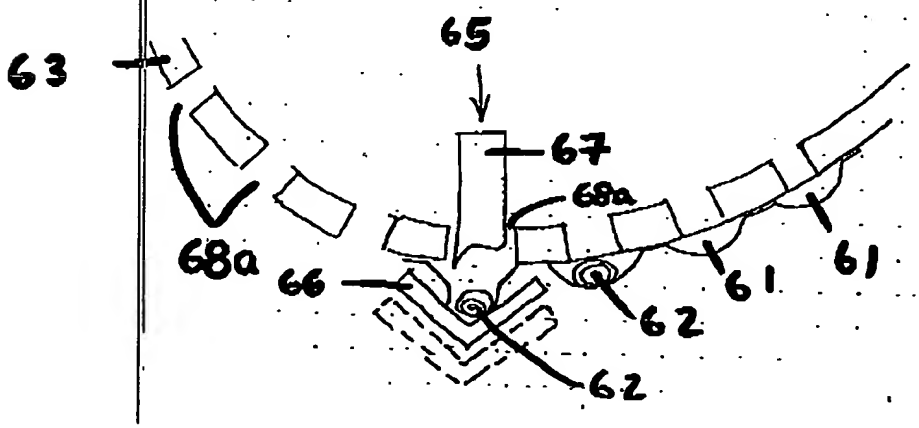



FIG.19

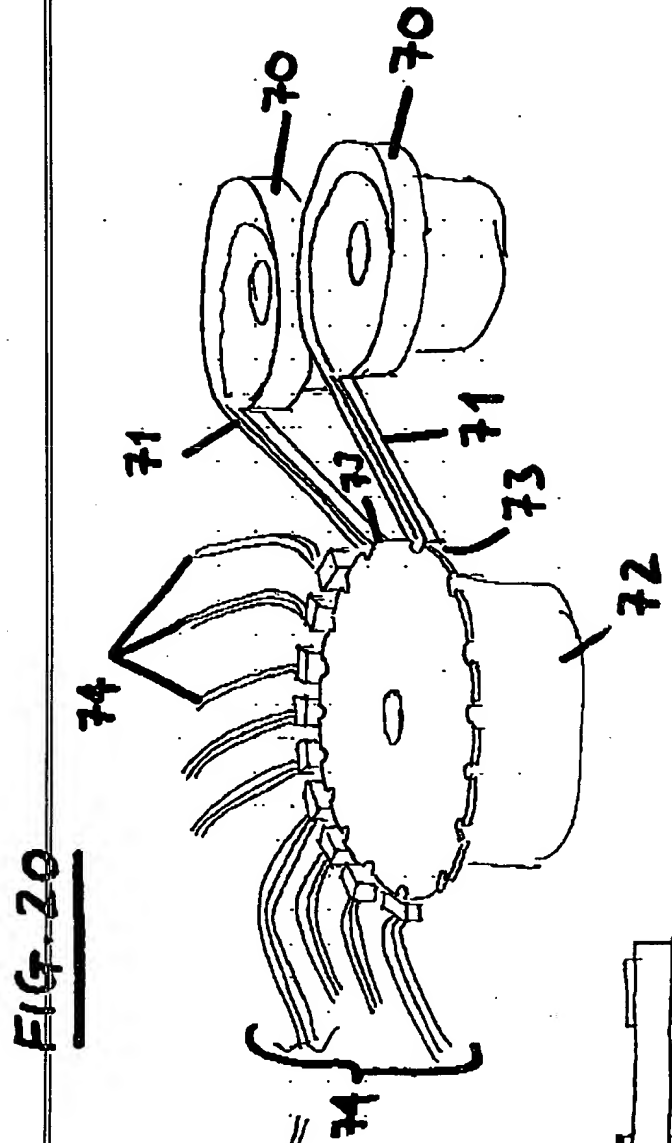



FIG. 20

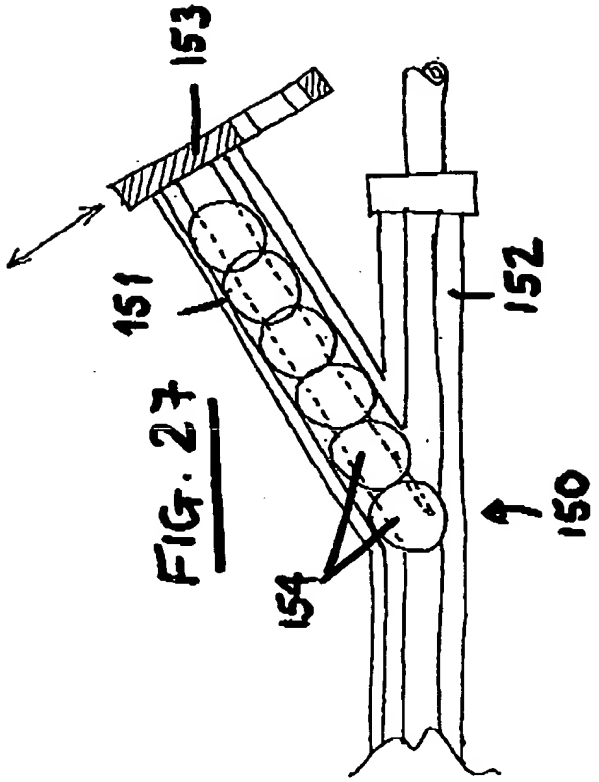



FIG. 27

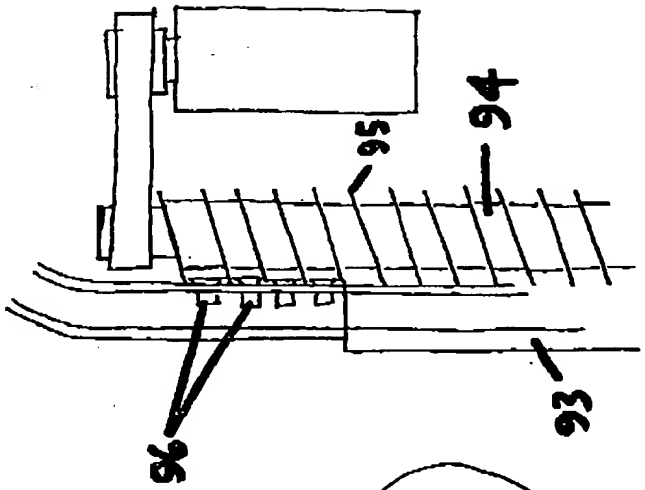



FIG 25a

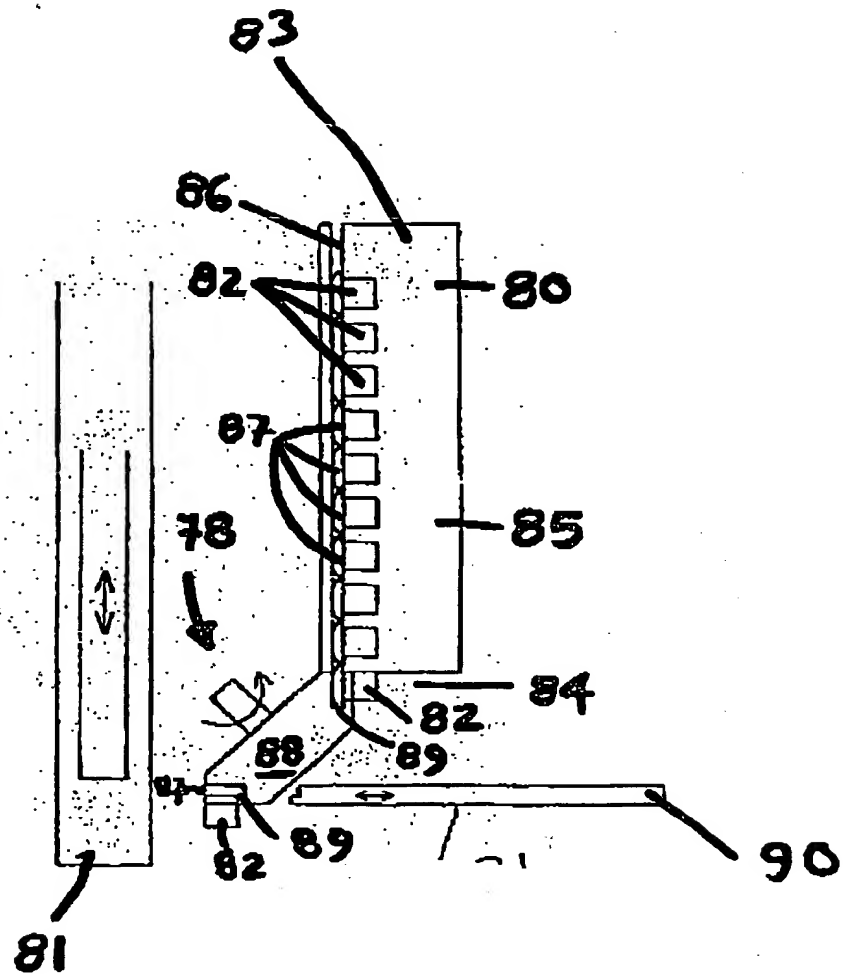



FIG 21.

FIG 24

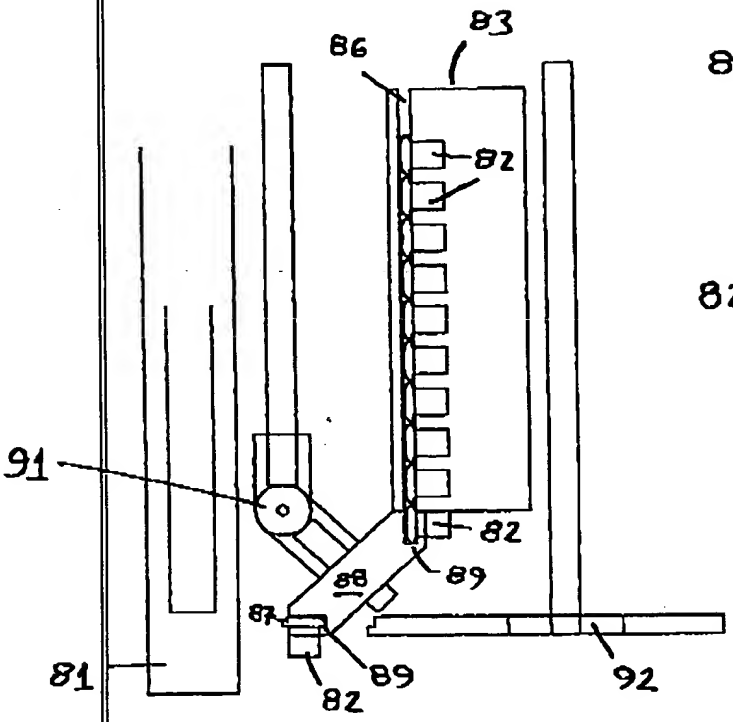
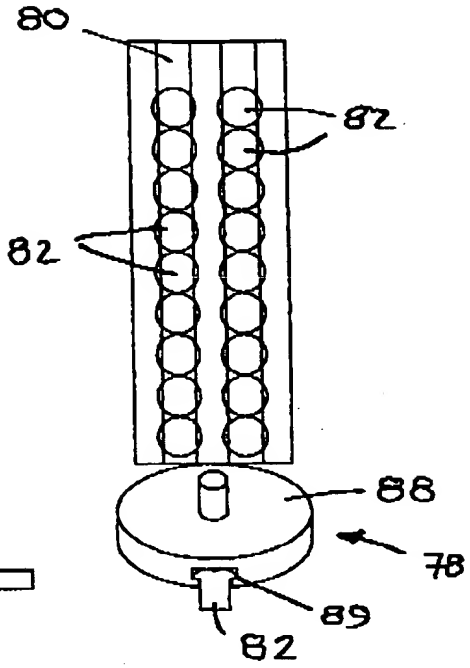



FIG 25



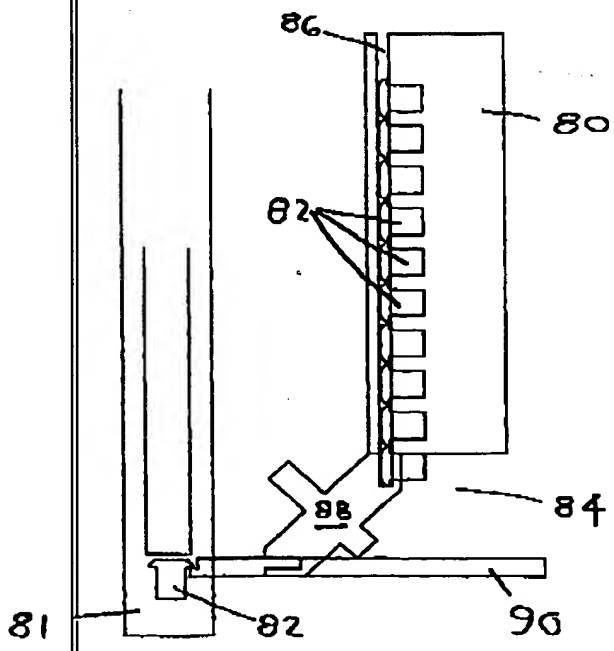




FIG 22

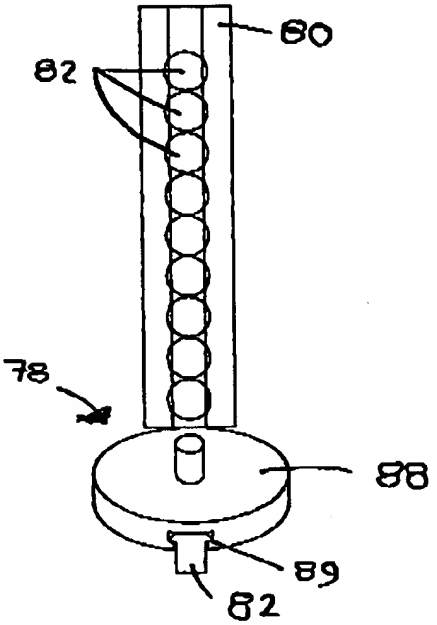



FIG 23

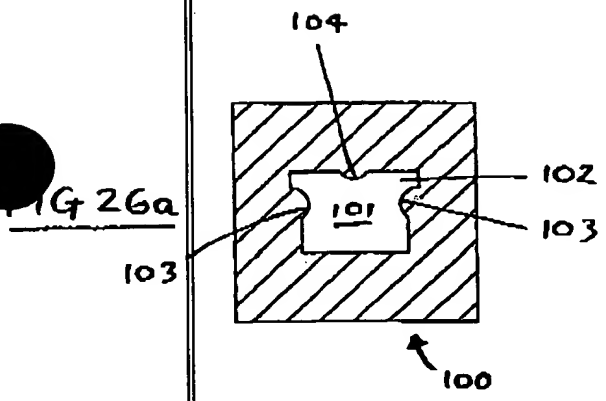



FIG 26a

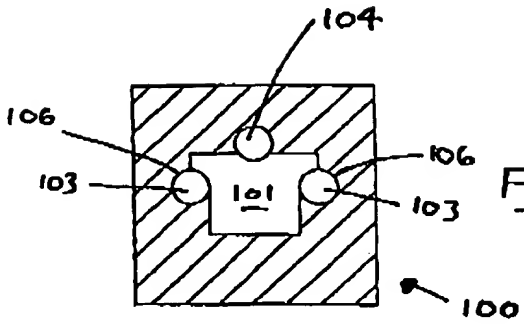



FIG 26b

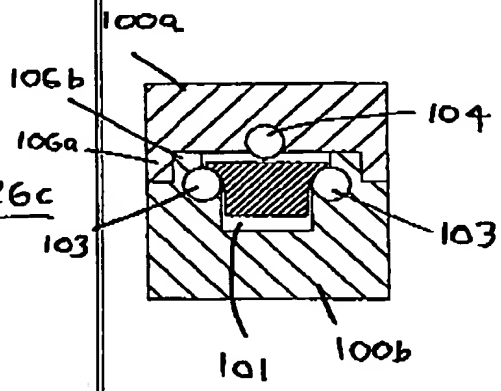



FIG 26c

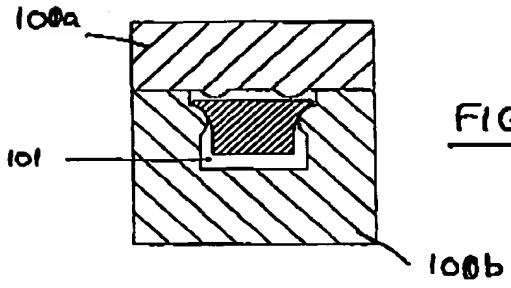



FIG 26d

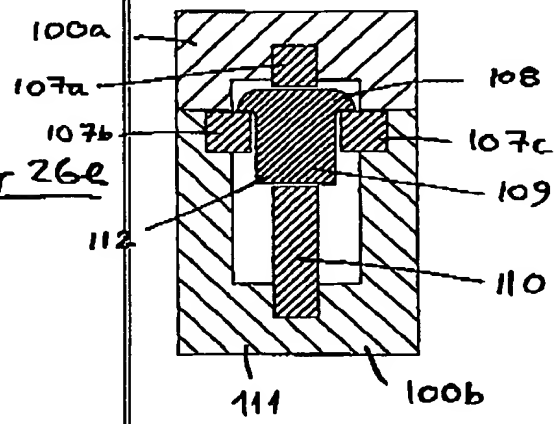



FIG 26e

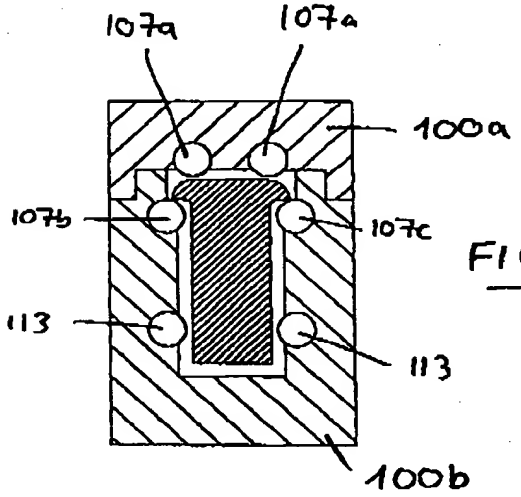



FIG 26f

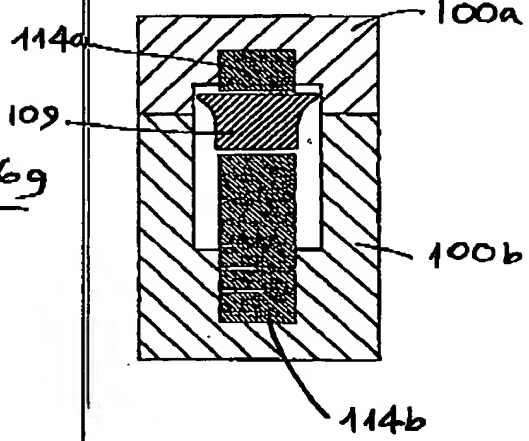



FIG 26g

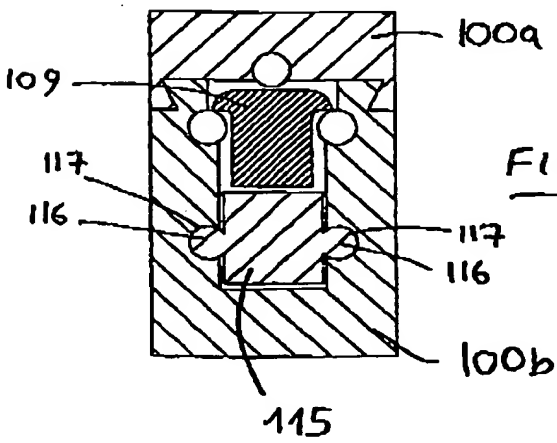



FIG 26h

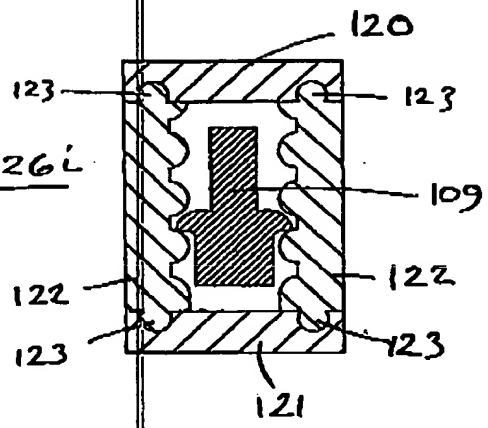



FIG 26i

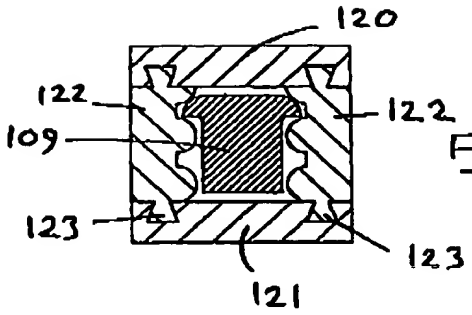



FIG 26j

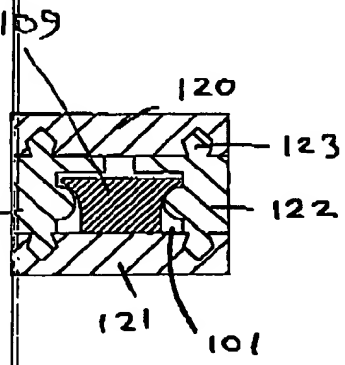



FIG 26k

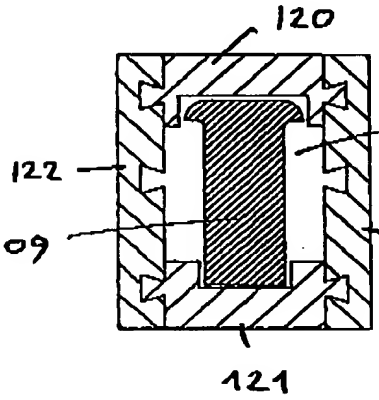



FIG 26l

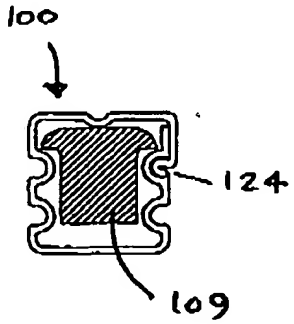



FIG 26m

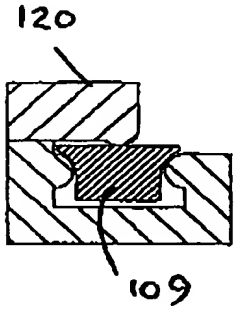



FIG 26n

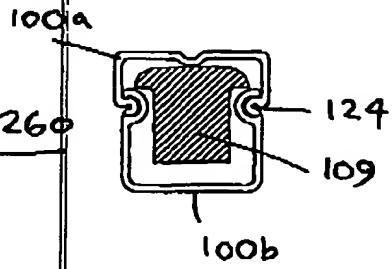



FIG 26o

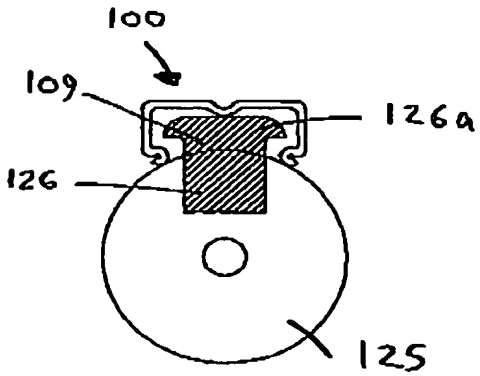



FIG 26p

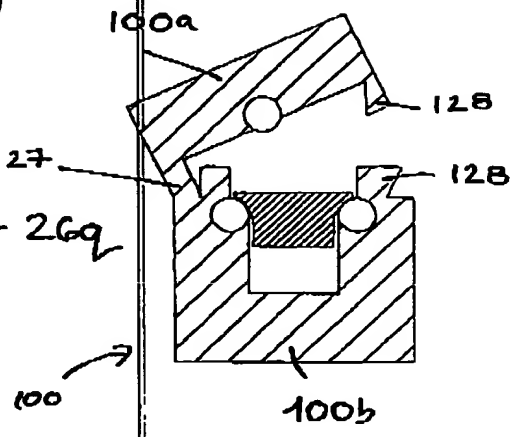



FIG 26q

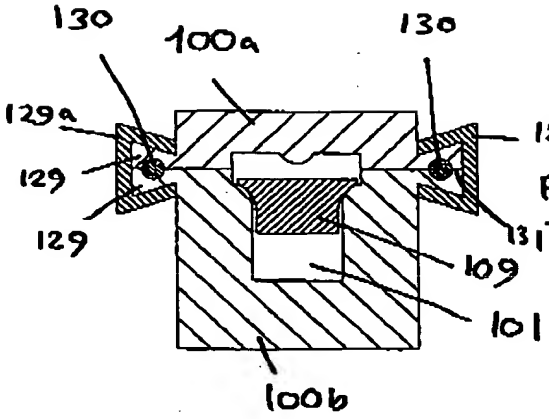



FIG 26r

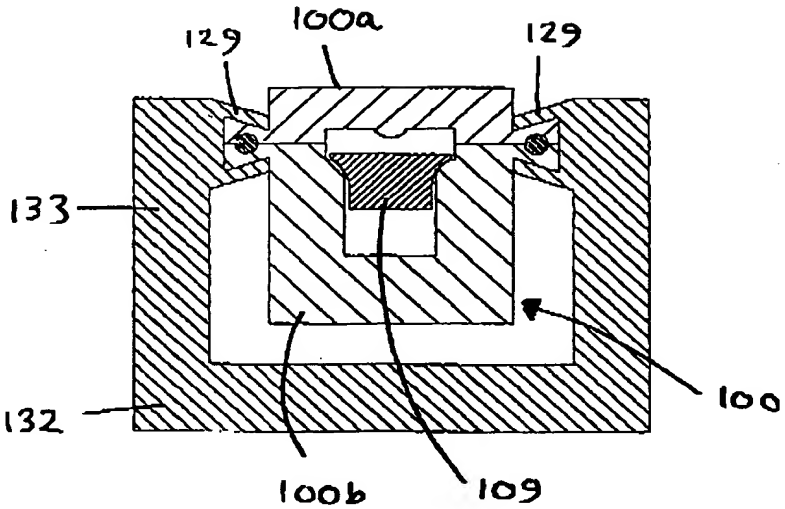



FIG 26s

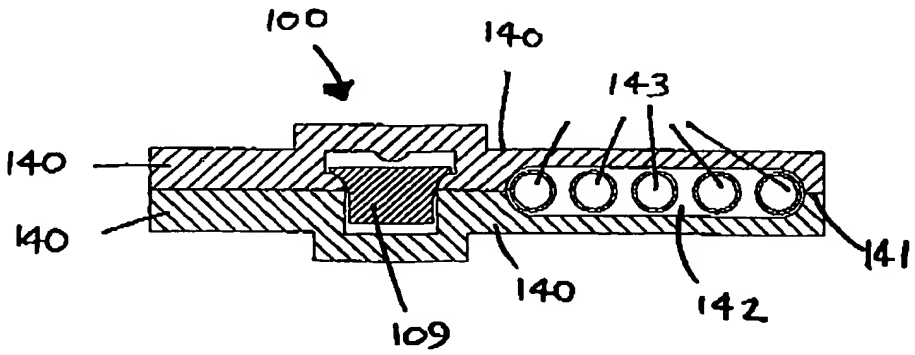



FIG 26t

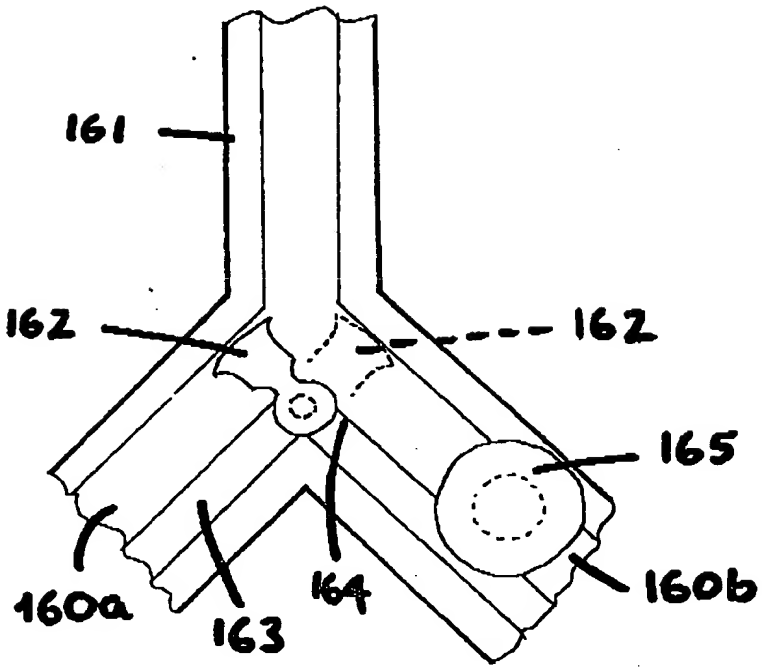



FIG 28

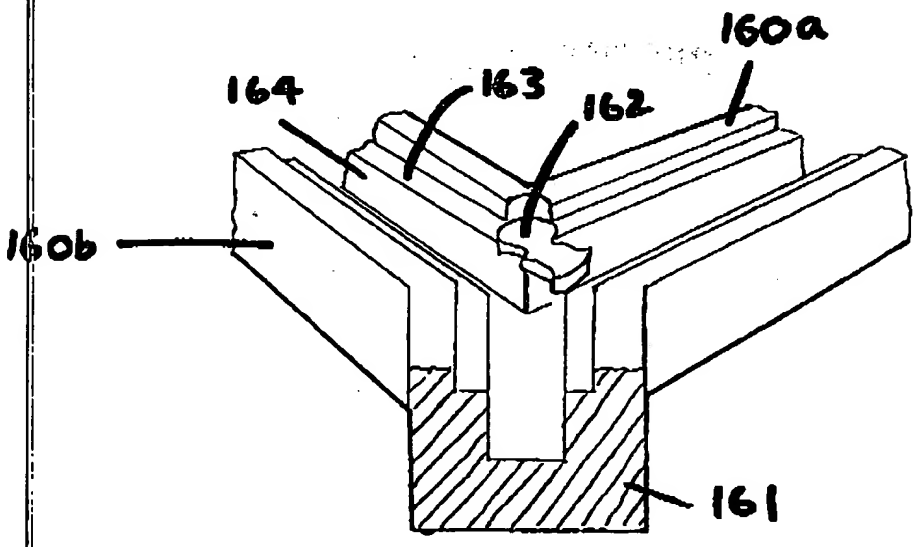



FIG 29

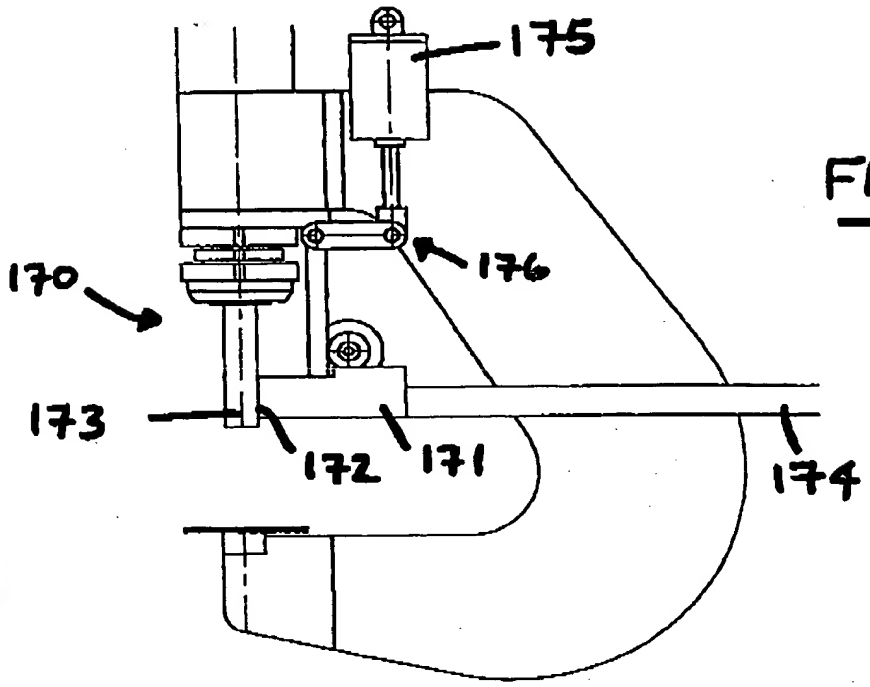



FIG 30

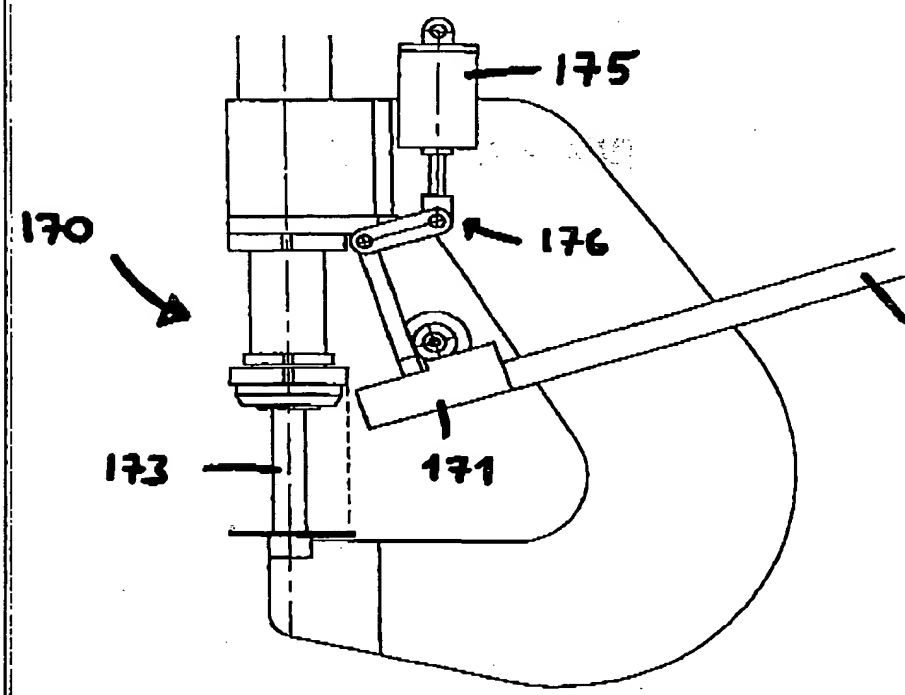



FIG 31

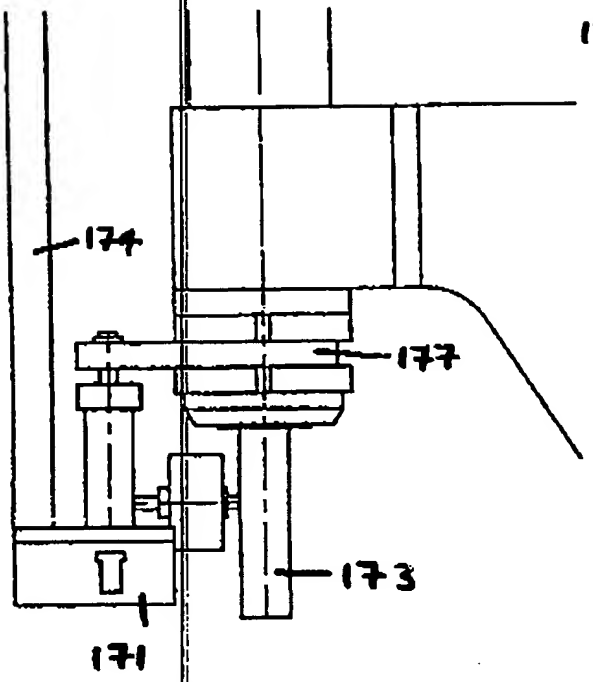



FIG. 33

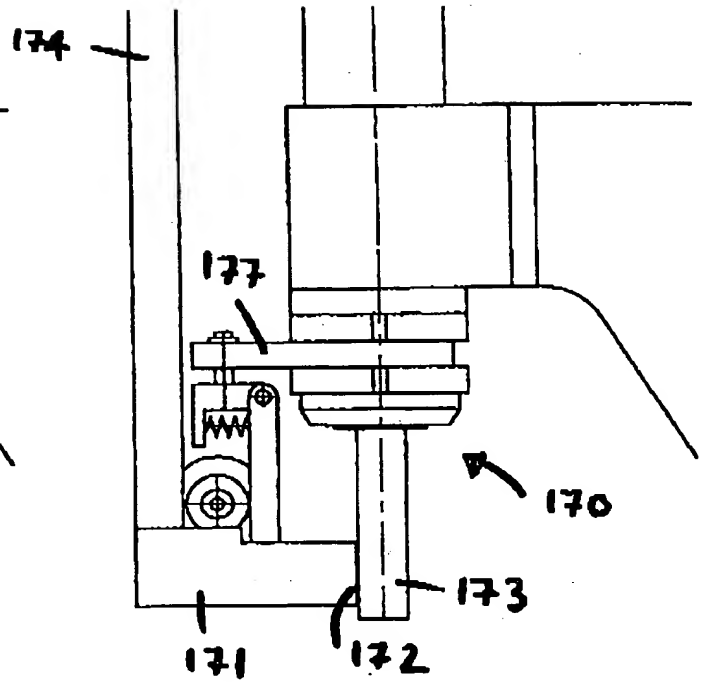



FIG. 32

FIG 37

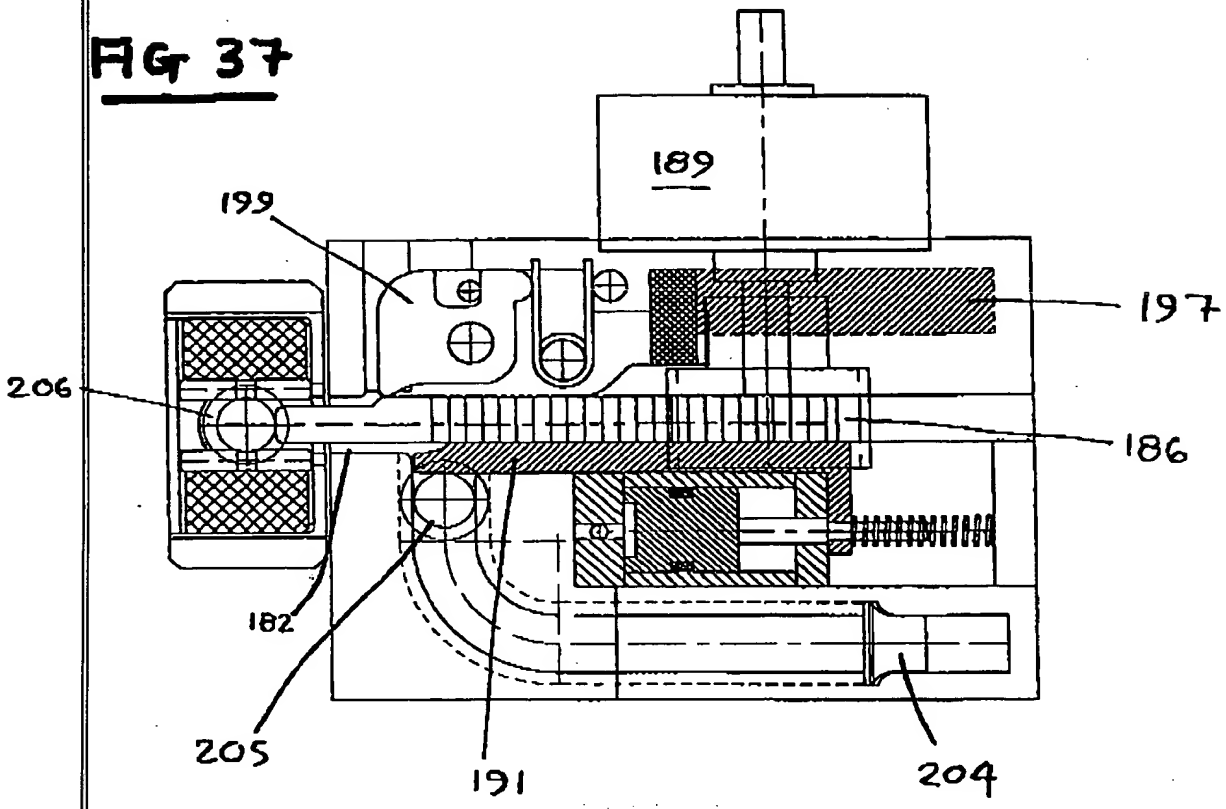

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FIG 34

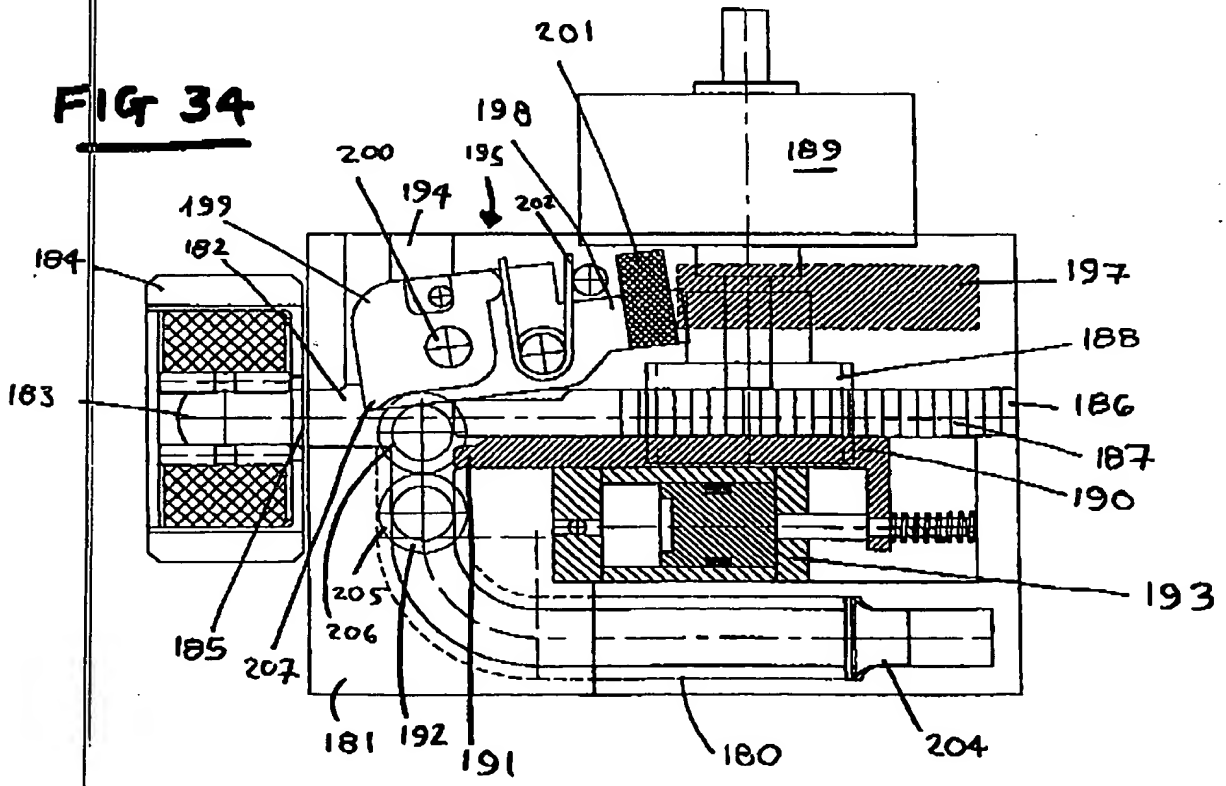
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FIG 35

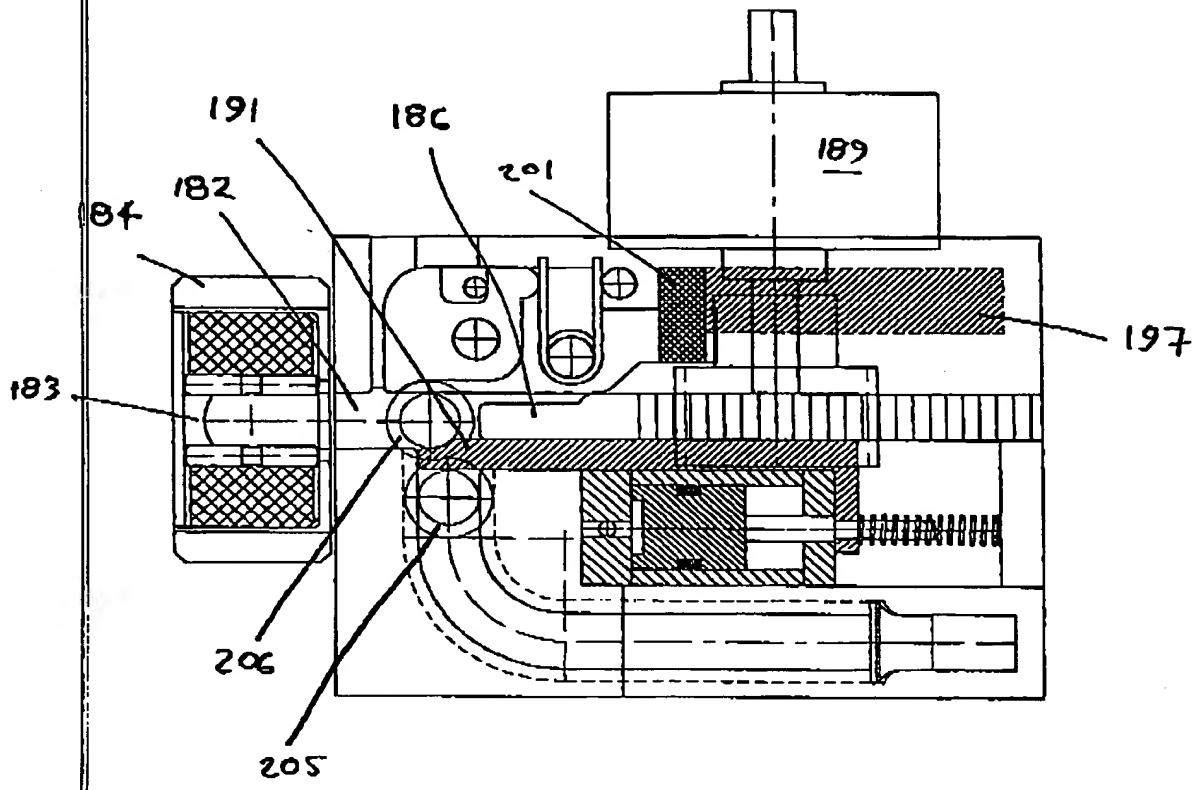
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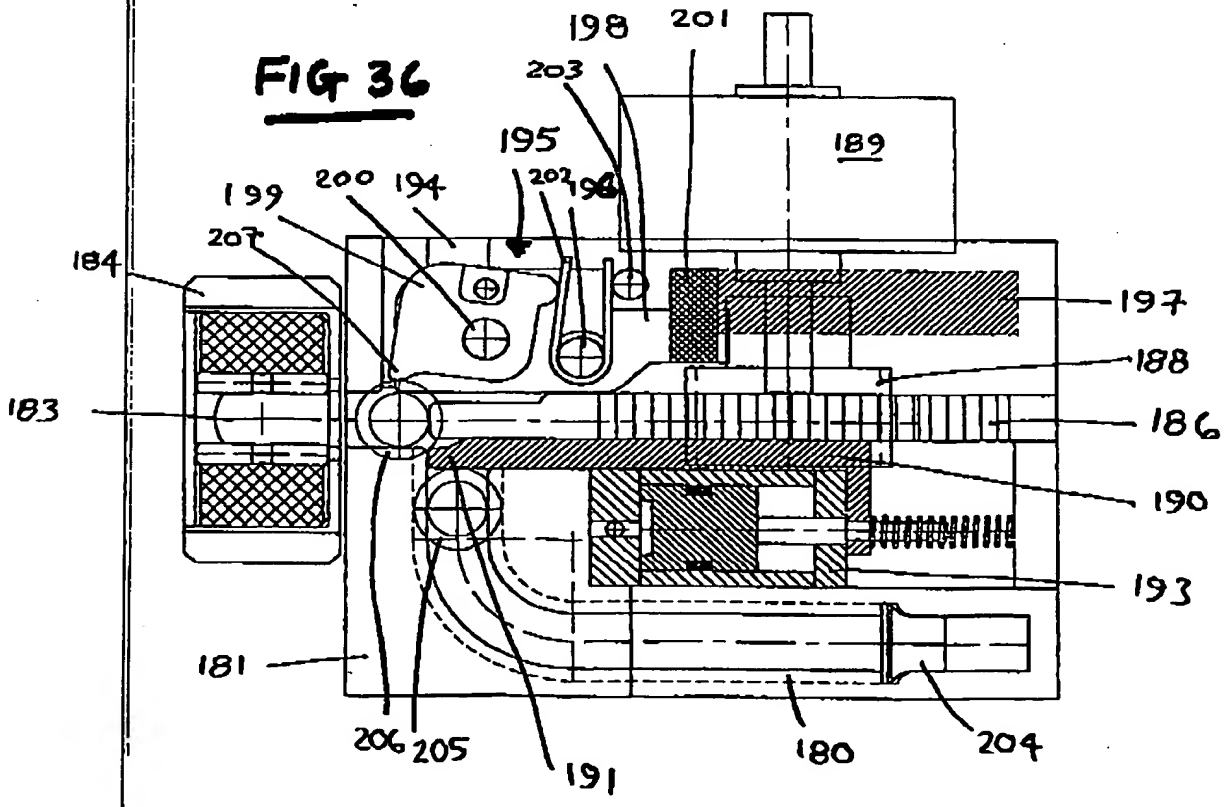
FIG 36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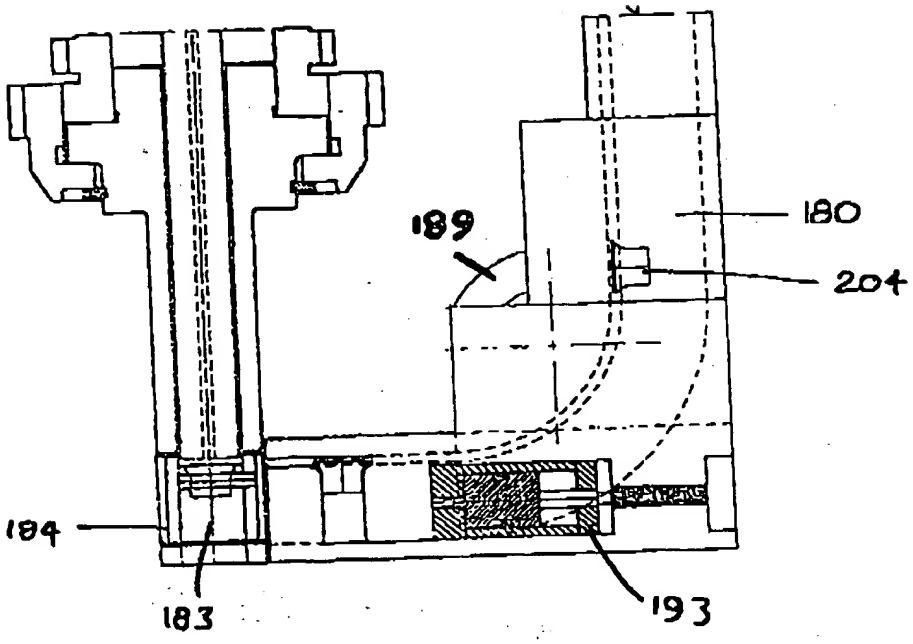



FIG 38

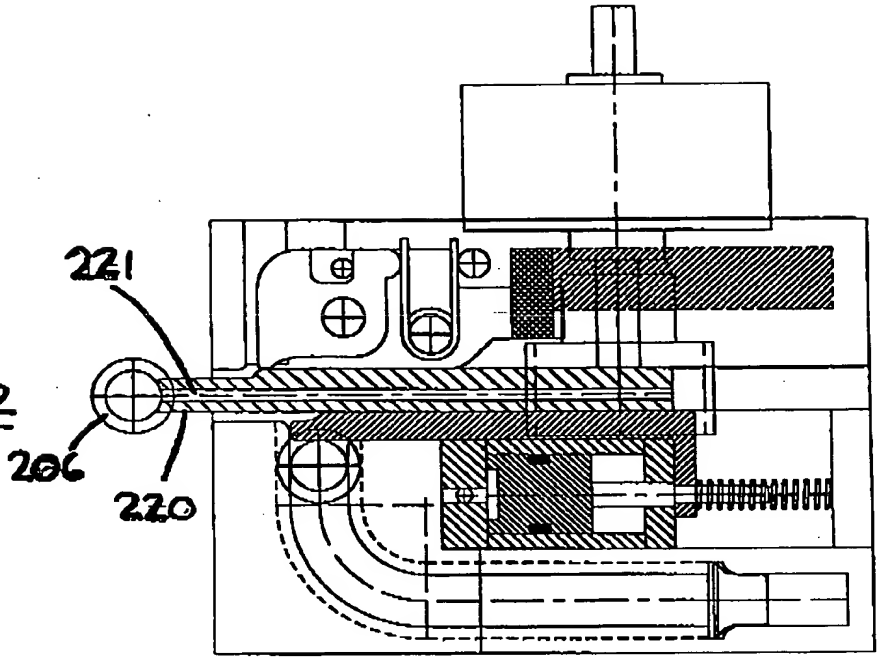



FIG 42

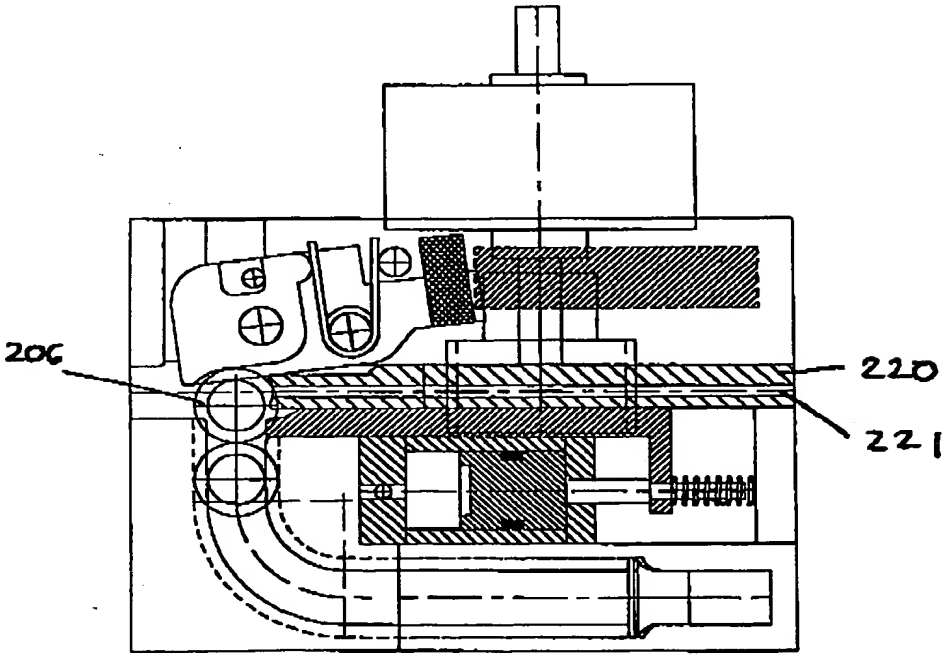



FIG 39

FIG 40

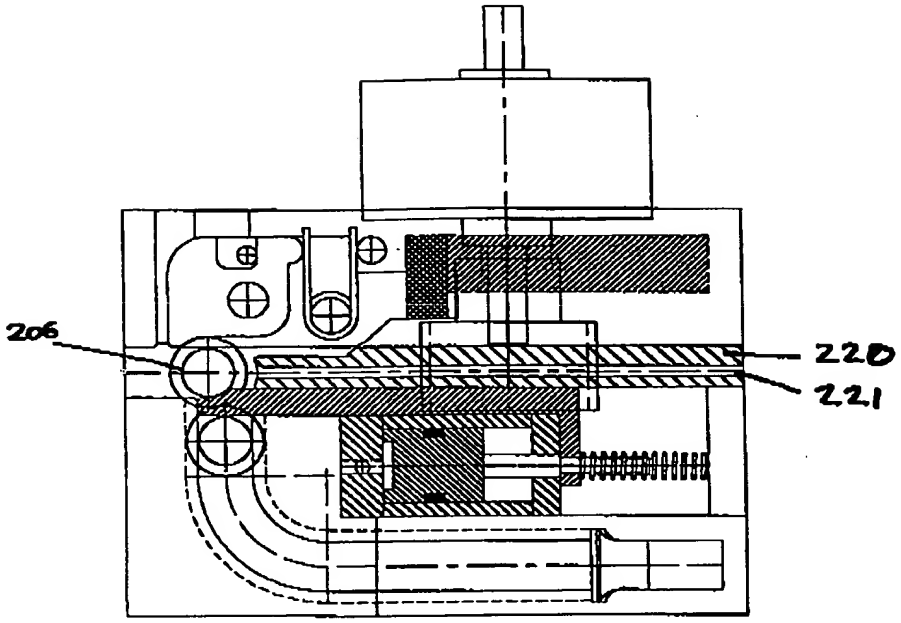



FIG 41

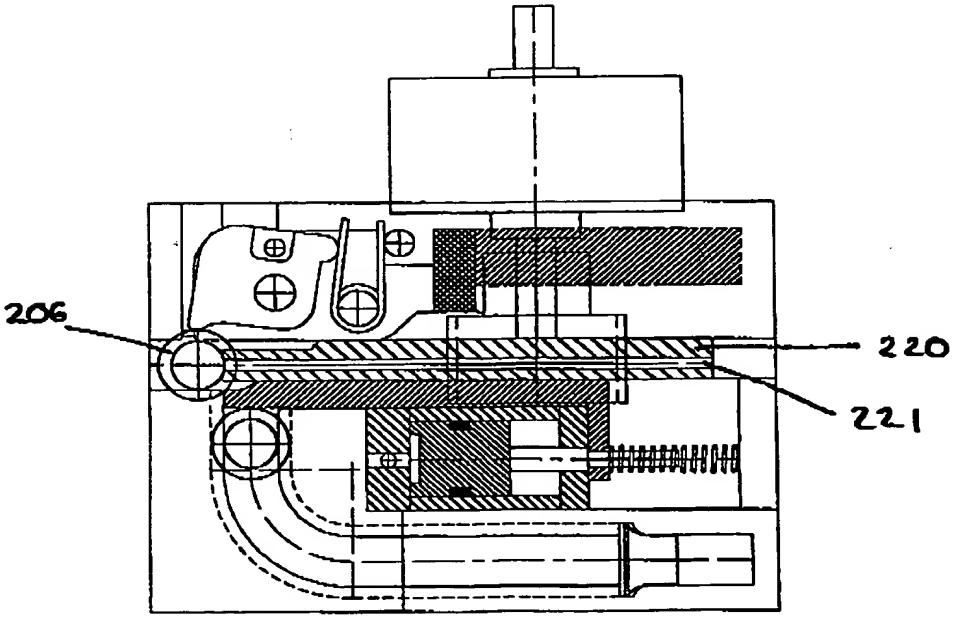


FIG 43.

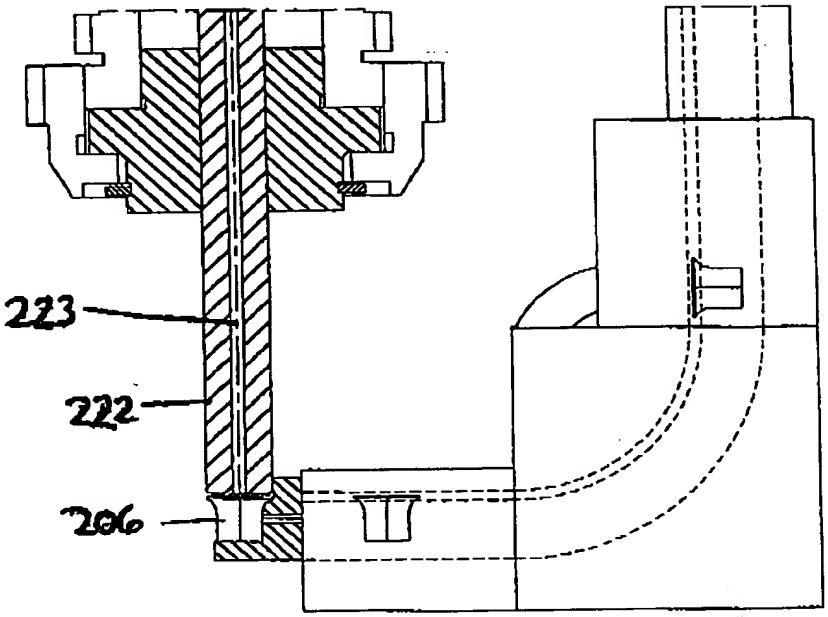


FIG 44a

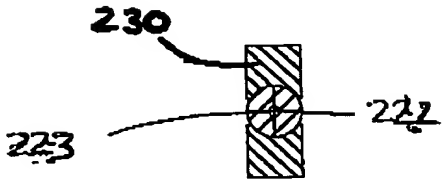



FIG 44

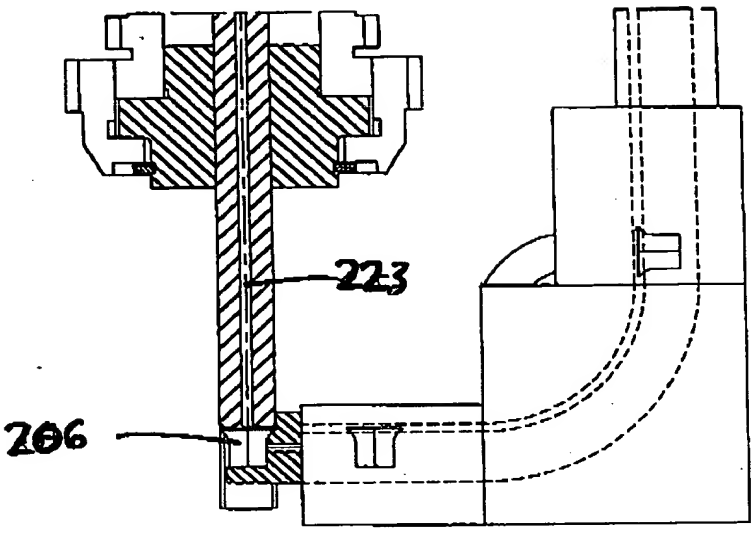



FIG 45a.

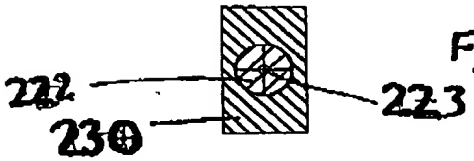



FIG 45.

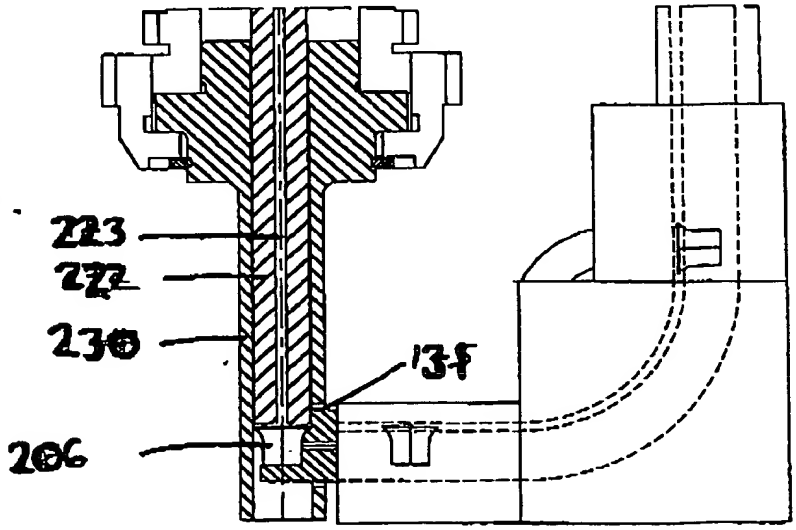


FIG 48

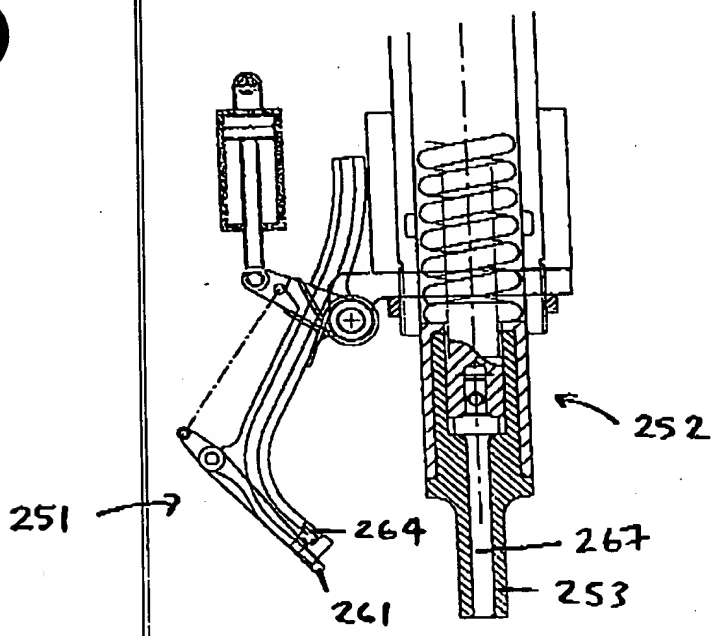



FIG 49

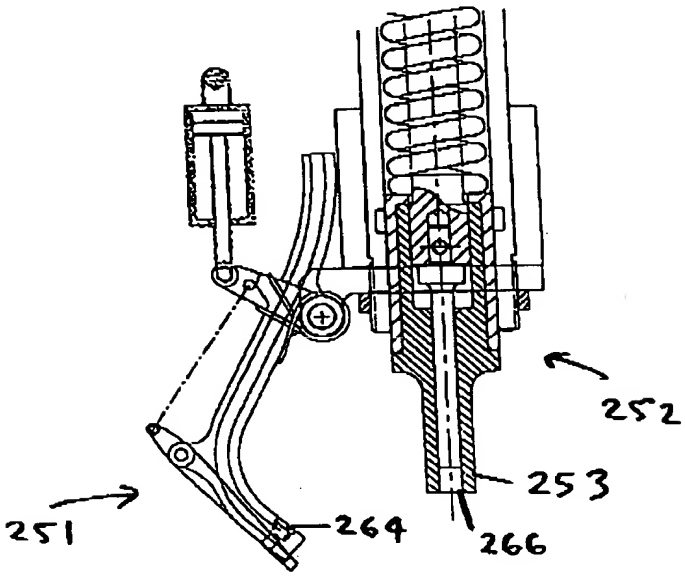



FIG 52

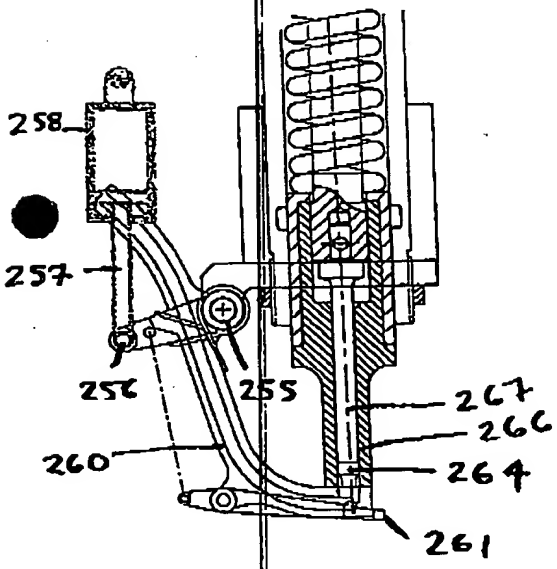



FIG 53

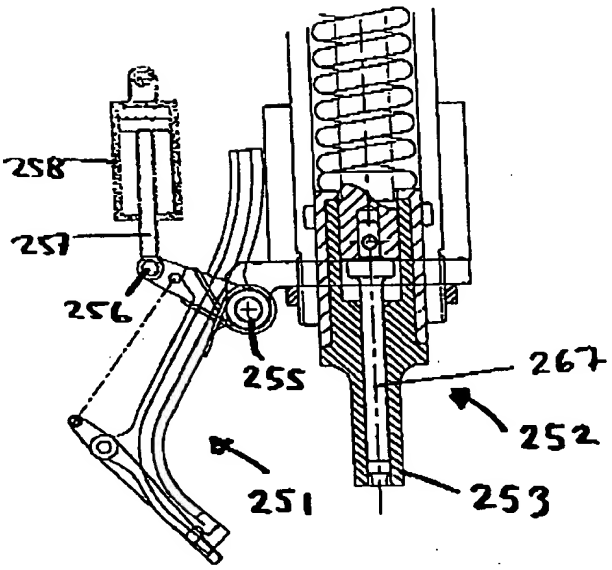


FIG 46

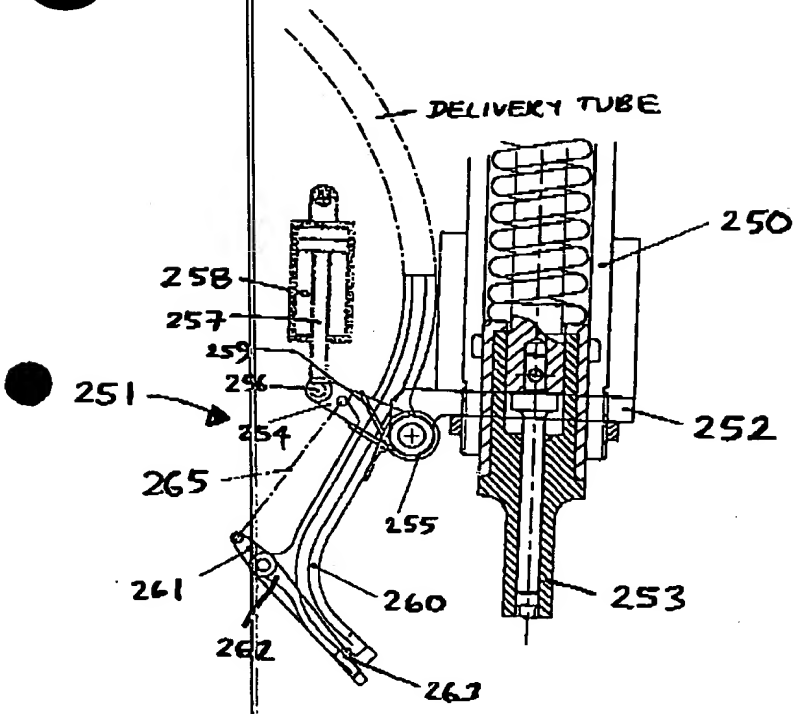



FIG 47

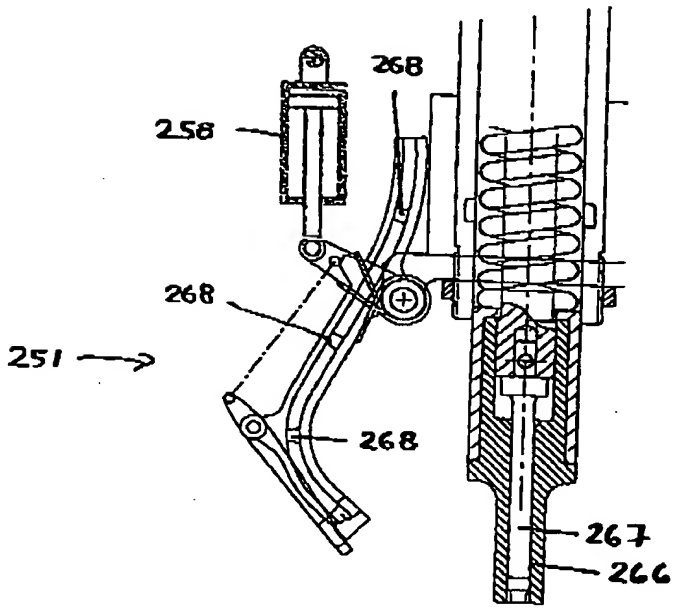



FIG 50

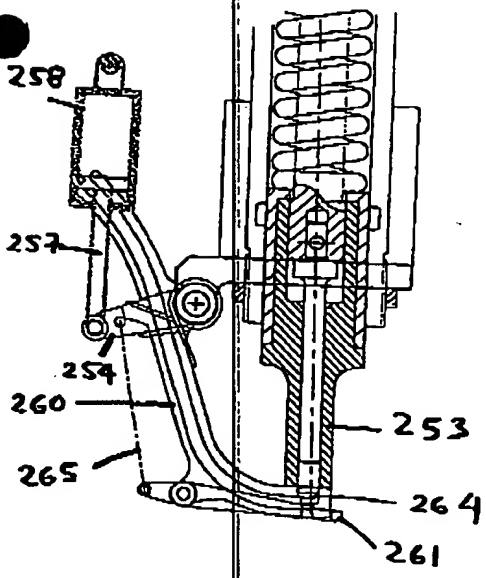



FIG 51

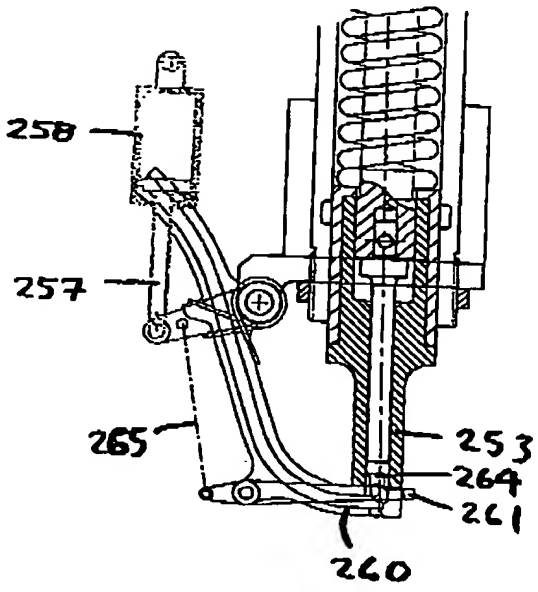


FIG 54a

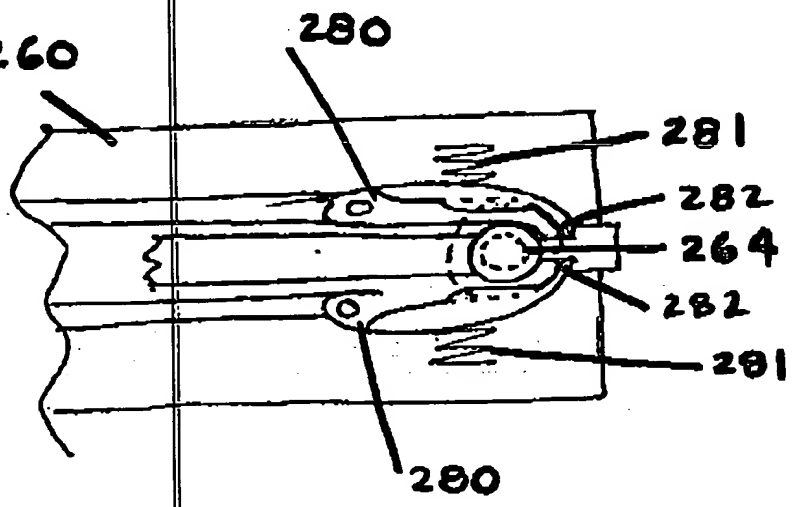
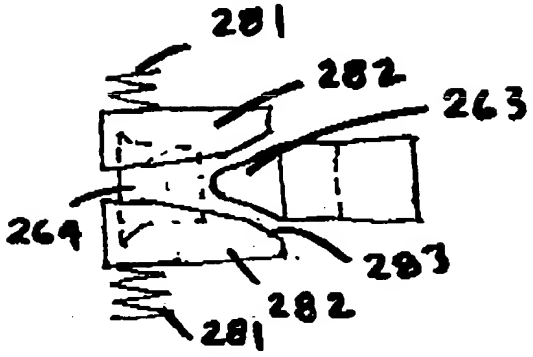



FIG 54b



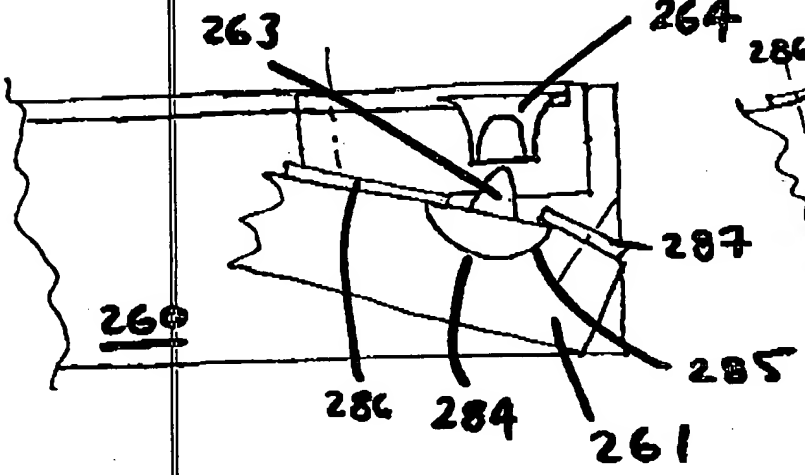




FIG 54c

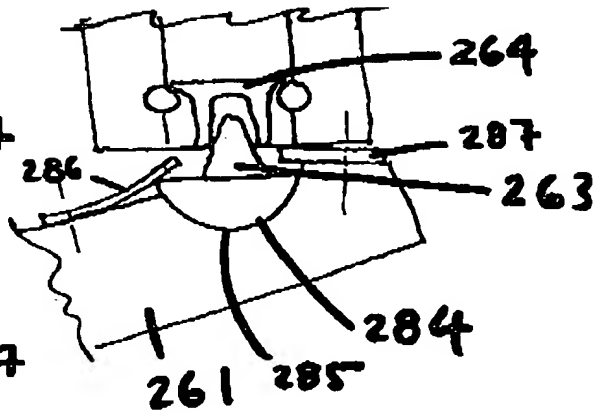



FIG 54d

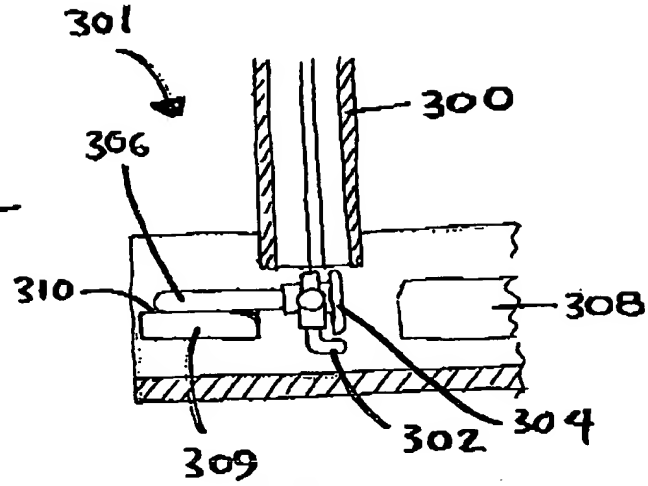



FIG 55

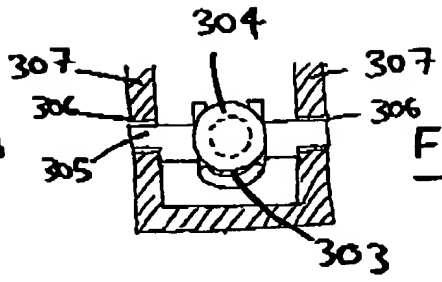



FIG 56

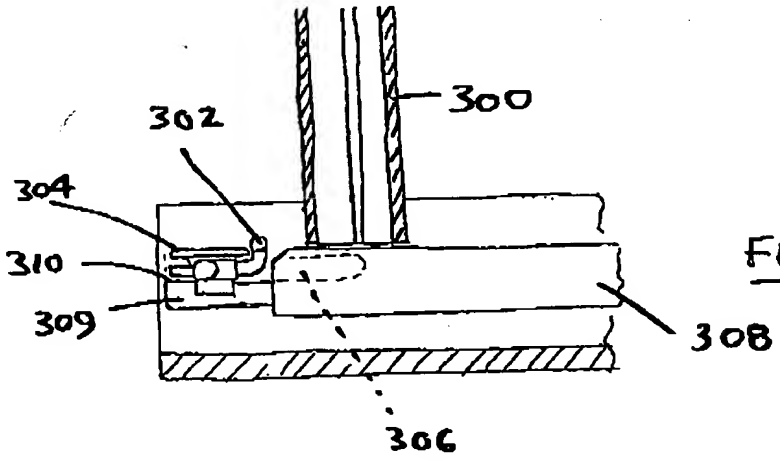



FIG 57

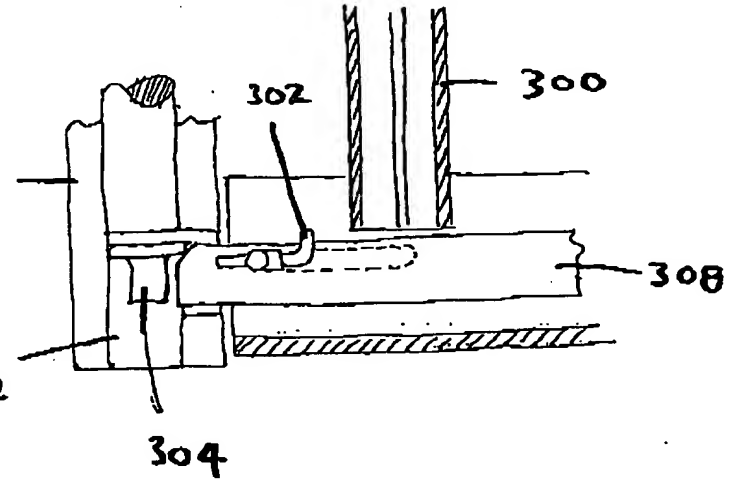



FIG 58

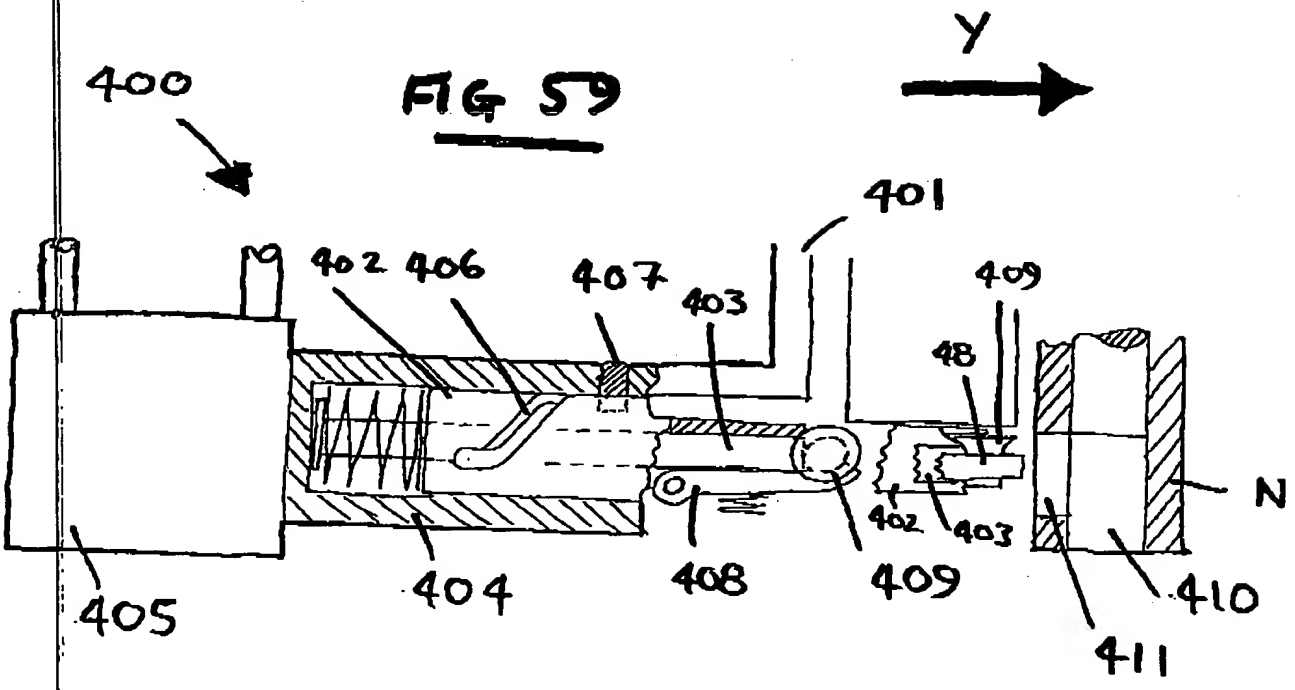

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FIG 59

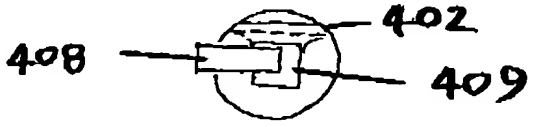
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FIG 60

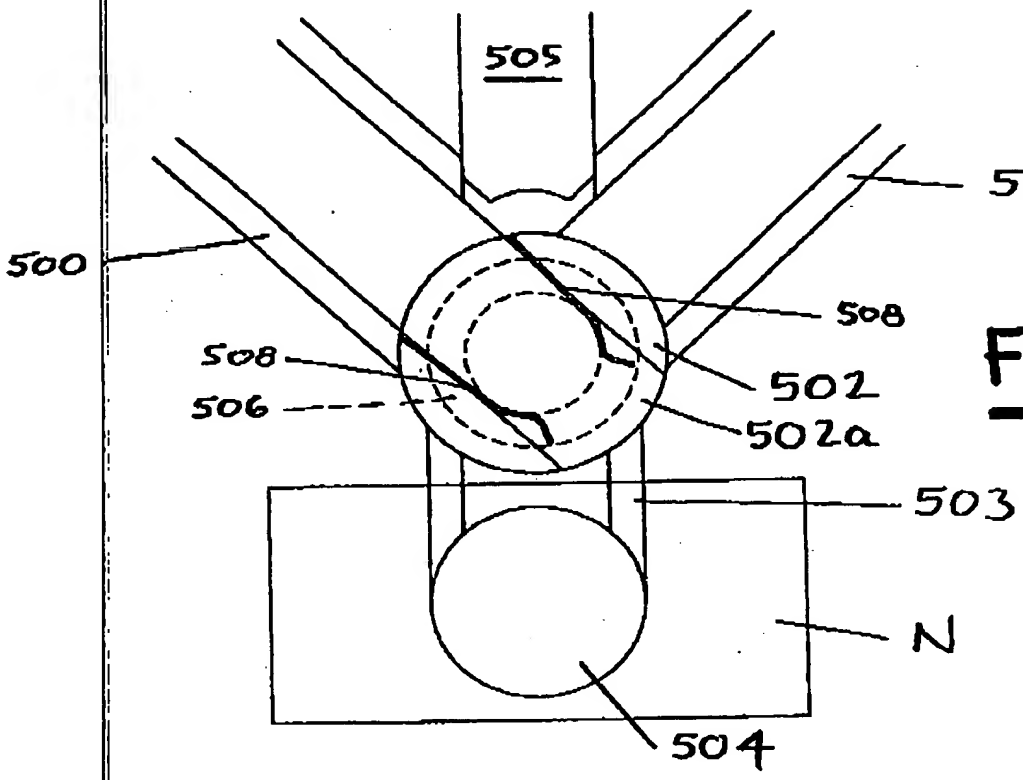
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FIG 61

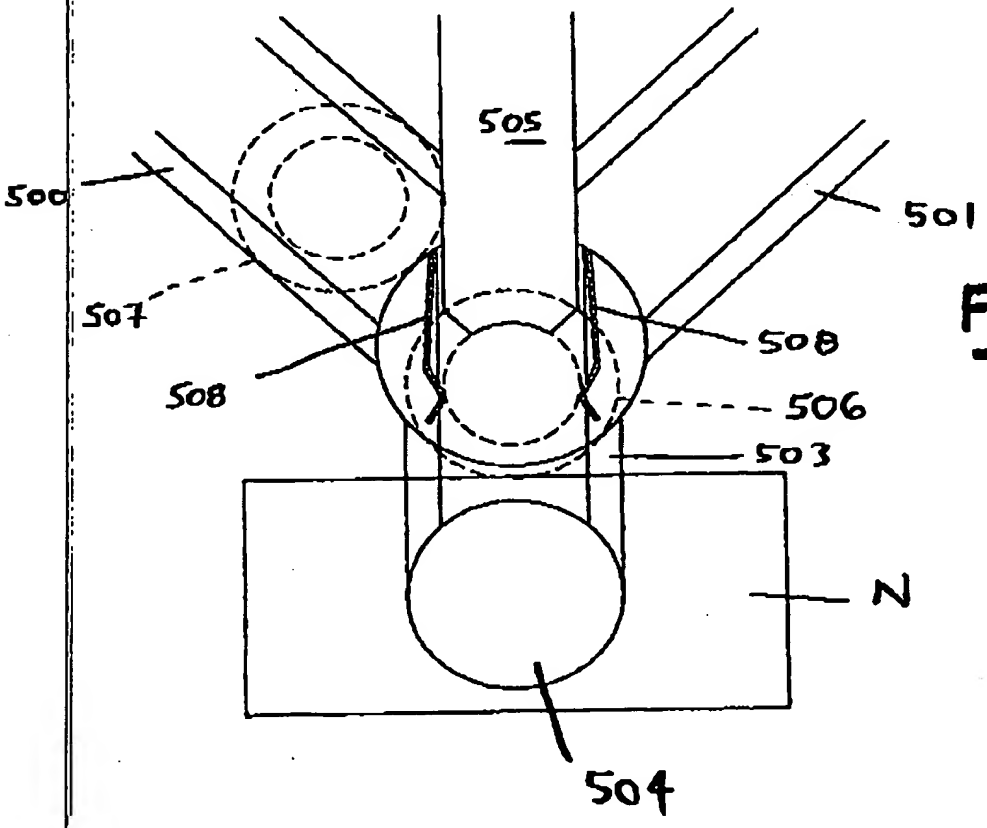
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FIG 62

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